Nothing must be allowed to interfere with the stream of armaments and other tools of war flowing from industry. Neither management nor labor can afford to be so lax in patriotism as to take unfair advantage of the urgency of the situation.

—JAMES G. HARBORD

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XLIII APRIL, 1943 WHOLE NUMBER 375

NEW EDITORS FOR GENERAL SCIENCE AND ZOOLOGY

New duties have absorbed the time and energy of some of our editors. Mr. Ira Davis has been our editor for General Science for many years and has given faithfully both time and energy for the good of this Journal and for the promotion of science teaching. In recent years his time has been so taken by other types of work that editorial duties must be relinquished. Mr. Lyle Stewart served as editor for zoology for a number of years but his excellent work in the field of educational films called him to Washington for special work in the Federal Office of Education where he is now serving as a specialist on the planning and making of war films for training our soldiers, sailors and students for victory.

As editor for General Science we are happy to announce the appointment of Dr. Walter A. Thurber, Supervisor of Elementary Science, New York State Teachers College, Cortland, N. Y. He comes to us rich in both education and experience. His college work includes work in electrical engineering, geology and paleontology at Union College where he received his Bachelor's degree in 1933. This was followed by the Master of Science degree at New York State Teachers College at Albany in 1938, and the Ph.D. from Cornell in 1941. In addition to teaching experience in the rural schools of the great state of New York, he has taught in a rural high school, a centralized school, and a city junior high school. At Cornell he majored in nature study and elementary science education. He is a member of Delta Upsilon, Eta Kappa Nu, Phi Delta Kappa and Sigma Xi, and is active as a scoutmaster and as a leader in scoutmaster training

courses. He is known to the readers of this Journal by leading articles he has published.

Mr. Howard F. Wright, a teacher of zoology in the Shortridge High School at Indianapolis, now takes up the work of our Zoology Editor. He graduated at Ohio Wesleyan at Delaware in 1928. This was followed by a year of graduate study at Indiana University previous to his work at Shortridge where he has been for the past fourteen years. In 1936 he received his Masters degree from the University of Michigan. He is already at work planning a definite program for his department.

TINY MAGNETS SPEED TEACHING OF EMERGENCY CODE TO ARMY AIRMEN

By sliding small alnico magnets around on a steel plate representing the earth, instructors now prepare panel code messages 200 times faster than formerly and hurry-up the training of Army flying cadets, report high-ranking officers of the Army Air Forces Advanced Flying School at Brooks Field, Texas.

When other means of communication is lacking or inadvisable, airmen rely on code patterns constructed on the ground by grouping rectangular pieces of canvas. Looking like rows of over-size stretchers, these code patterns can be read from a height of 10,000 feet.

To learn to read the signals, cadets studied model panels on a blackboard in ground school. The models are pinned and repinned in various code positions as many as a hundred times during a single class period, thus wasting much time.

Now a steel plate replaces the blackboard and alnico magnets, developed by the General Electric Company, serve as models. These can be shifted from one code pattern to another in only 1/200 of the time required to pin the old models.

Perhaps the first use of this ingenious method of classroom instruction was made by Dr. A. F. Blakeslee, at the Carnegie Institution of Washington laboratories at Cold Spring Harbor, N. Y. Years ago he hit upon the idea of sliding flat bar magnets about on an iron sheet to show his students the arrangement of chromosomes, the heredity-carrying bodies in living cells.

DR. CHARLES GLENN KING RECEIVES PITTSBURGH AWARD FOR OUTSTANDING WORK IN CHEMISTRY

For outstanding work in chemistry, Dr. Charles Glenn King, scientific director of the Nutrition Foundation, Inc., was given the Pittsburgh Award of the American Chemical Society's Pittsburgh Section.

Dr. King isolated and identified vitamin C and has done work on enzymes and the chemical structure of fats and sugars.

On leave from the University of Pittsburgh, Dr. King is now visiting professor at Columbia University and scientific director of the Nutrition Foundation to which 16 food companies have subscribed more than a million dollars "for improvement of the diet and health of the American people."

THE PSYCHOLOGY OF HIGH SCHOOL PHYSICS

THOMAS MORSE BARGER
Illinois State Normal University, Normal, Illinois

The name physics as applied to a subject for study in our schools is comparatively new. It has been in general use for about sixty years. The subject to which this name is now applied has been in school curricula for a great many years. Many of its teachings were first included in the subject Philosophy and later under the head of Natural Philosophy. Some of the phenomena now included in this study were known to the early alchemists and can be traced to the knowledge of the earliest philosophers. Of course it is questionable whether their knowledge of these phenomena was clearly enunciated or could be called a science even in the loosest use of the word.

The subject of physics attempts to explain, in understandable language, the physical phenomena of the universe. The psychology of adolescence, as well as good pedagogy, demands that a course in physics for high schools should include such phenomena only that directly touch the pupils' everyday lives. And such phenomena should be chosen by the instructor for study that will enable the pupils in the class to live more intelligently. Furthermore, the content of the course should never be beyond the comprehension of the pupils taking it. As Judd says: "The school can help pupils to master science only when it arranges its courses in this field in conformity with their abilities."[1] It is evident then that a high school course in physics should be limited in its scope, and all will not have the same content. Physics courses for rural schools should differ noticeably from those offered in city schools, and courses in boys' technical schools, such as Crane and Lane in Chicago, should differ widely from those offered in girls' schools like the Margaret Fuller high school in the same city. Those acquainted with the tremendous scope of the subject, know that these limitations may be met and still have enough material available for a full year's work in any type of school.

THE PSYCHOLOGY OF THE SUBJECT

Physics is one of the best subjects in our high-school curriculum to develop the proper attitudes, ideas, physical and mental

[1] Judd, C. H., *Psychology of Secondary Education*. Ginn & Co., Chicago. Chapter XV, page 327.

habits, and skills, and to help the pupils in living intelligently and fully.

Attitudes. We see evidence that at least the following seven attitudes are developed: 1. Interest in the subject and in other subjects. 2. Interest in phenomena about the pupil. 3. A judicial attitude towards the work. 4. Attention. 5. Exactness in speaking, thinking, etc. 6. Inquiry. 7. Work, or study.

When the course in physics is made up as suggested above, it is found that a majority of the boys and girls soon develop a *favorable attitude toward the subject.* The pupils are few who do not admit that this subject teaches them more than any other and also that they work harder upon it.

Physics also develops a *right attitude toward other subjects* in that it leads the pupils to look for the "why" of things about them, and it also teaches that all phenomena of nature have reasonable causes for being. This helps them to understand that there must be a reason for mathematics, history, English composition, etc. This right attitude carries over to things, persons, and environment in general.

A *judicial attitude* toward their work, rather than "jumping at conclusions," is acquired by this study. The pupils develop this by the demonstrated and experimental work if it is properly presented to them. Reasonably accurate results and logical conclusions must be achieved and the pupils soon learn to analyze thoughtfully what they have seen done or have done themselves, before reporting upon it.

Attention must be given to the directions and to the discussions in the class or confusion soon results. This is one of the first observable attitudes developed.

Another important attitude which the pupil acquires is that of *exactness.* This is developed in his speech, as he must use exact terminology in referring to the apparatus, to his results, to the laws enunciated, and to the meanings of the words; he must not confuse force, work, power, energy, for example. His thinking must be exact if his conclusions are to be of worth. The successful performance of experiments with apparatus also encourages the development of the above named attitudes.

The pupil in the physics class develops the attitude of *inquiry,* because he soon learns that without it he misses much that his fellows are getting. Realizing that some phenomenon is not understood, then attacking it until the whole procedure has become clear and comprehensible is a cause of great satisfaction to

the student. This subject offers hundreds of such opportunities and the teacher should place constant emphasis upon the value of investigation.

In developing the above named attitudes, the pupils have almost unconsciously acquired the attitude of *work* or "study," as they usually speak of it. And this is one of the most valuable school accomplishments.

Ideas. Physics certainly develops the following ideas: 1. Mental images. 2. Imagination. 3. Word meaning. 4. Facts or statements. If it doesn't it is because something is radically wrong with the teacher, the pupil, or the content of the course.

A pupil who successfully performs his work in physics must be forming constantly *mental pictures* of the construction of the machines used, of the laws enunciated, and, in several cases, of the substances with which he is working, as these cannot be perceived by the physical eye.

Most of the gases cannot be seen, so that mental pictures are absolutely necessary to understand Boyle's, Charles', and Gay-Lussac's laws, etc.

Forces, heat, sound, light, and electricity cannot be seen by the physical eye, consequently the pupil must form definite and reasonably true mental pictures of all of these before he will be able to read intelligently the statements in the textbook or understand about what the instructor is talking.

Even in mechanics mental imagery is developed. The pupil soon learns to see levers in scissors, nut crackers, the hammer, and other home utensils. In hills and the approaches to garages he sees nature's and man's method of producing inclined planes. The screw driver soon means to him a simple way of increasing mechanical advantage, and so on with the other simple machines and their applications.

But his mental imagery does not stop here. He must picture convection currents before he can understand how his home is heated; he must have a different set of images if the is to appreciate the operation of his automobile, etc.

Without ***imagination*** none of the above named mental images could be formed and these will be true and easily formed in the exact ratio to the use of the pupil's imagination. Without imagination it is impossible to grasp the relation between heat and temperature, to appreciate the complete spectrum with its series of varying wave lengths, to picture the positive and negative charges of static electricity, or the stream of electrons making

up the electric current. There is almost no limit to similar illustrations that might be mentioned.

Given a teacher with proper ideals and experience, the pupil will increase his *vocabulary* more than in any other of the curriculum studies. The nomenclature of physics is fairly well established and in order to read the textbook, understand the teacher, or comprehend outside reading references, the pupil must know and understand the meanings of the words used. Such words as weight, mass, gravity, pressure, temperature, heat, convection, radiation, etc., cannot be guessed at as to meaning but must be known, if the pupil is to grasp what is being said by the author. He must also know the names of the parts of the apparatus used, the instruments worked with, etc., This increase in vocabulary is largely technical, but we are living in a highly developed mechanical age and this technical vocabulary will prove of great value to him in his later life.

Facts or Statements. Here again the pupil learns and develops wonderfully. Careless, slip-shod statements of procedure or of laws illustrated should not be tolerated. If the pupil grasps the meaning of an exercise or of the results obtained from a set of data, he can make a definite and exact statement of his findings, otherwise he has not accomplished what is expected of him by the laboratory guide or by the instructor. Probably no other subject in the pupil's high school course develops this accomplishment to the extent that physics does.

Physical Habits. Given an earnest, careful and exacting teacher, the pupil will develop habits of *neatness*, *carefulness*, and *observation*. This is true whatever the subject may be, but physics is especially well adapted to encourage the formation of such habits. The drawings of the apparatus used, the solution of problems, the performance of experiments, the tabulation of data and results, the form for writing the experiment, and the writing itself, serve as strong stimuli to become habitually neat, careful, and observant.

It is true that habit formation requires constant repetition and, if the pupil is held for neatness, carefulness, and observation in but one subject, it is somewhat doubtful just how lasting such acquisitions may be. The conclusion is that teachers of all subjects should be as exacting as the physics teacher. It is impossible for a slovenly teacher to inculcate the above named desirable habits in his pupils.

Not all pupils acquire these habits. A year of work in one

subject cannot undo the effect of years of previous practices. But the author knows of many instances of those in whom the above habits have been instilled or greatly developed by the work in physics.

Skills. It is a question in the minds of many educators whether skills are acquired in any class in school, but physics at least develops four skills: 1. General school skills, 2. Laboratory skills, 3. Thinking, 4. Study skills. The general school skills are drawing, writing, spelling, and pronunciation. The laboratory skills are manipulation of apparatus and measurement making. The study skills are study and constant review.

Numerous cases may be cited where a very marked and permanent improvement in drawing, writing, spelling, and pronunciation has been made in the physics class. The skills are possibly already there, but upon being convinced that such skills are not only desirable but necessary, they were encouraged and developed by the pupils. Poor spelling and pronunciation, for example, are a result of a lack of observation and attention. If a habit of careful observation is developed it will show itself in the improvement of the above named accomplishments. While skills may not be produced outright, they are capable of cultivation and improvement and the subject of physics does this.

The habits of carefulness and observation will carry over and make the pupil a better manipulator of apparatus, and the data and results obtained from weighings and measurements will be dependable.

As has been stated, the very nature of the subject of physics, as well as the method of procedure, encourages reflective thinking. It is a question whether a pupil can be taught to think, but he can be shown *how* to think and encouraged to try upon all occasions and this subject furnishes almost constant opportunity for thinking. As Morrison says, "For the purpose of general education, toward the end of the secondary period, the sciences become properly methods of thinking, of attacking, and studying their environment."[2]

Closely connected with thinking is the skill or habit of constant review, a phase of study. Many of the terms, laws, and principles, developed in the early part of the work are used throughout the year. The pupil must keep these in mind and

[2] Morrison, H. G., *The Practice of Teaching in the Secondary School.* The University of Chicago Press, Chicago. Chapter XI, p. 173.

this necessitates constant review. A few examples are force, work, power, and energy; the molecular theory of the structure of matter; the characteristics of forces, motions, and waves; the laws and principles of liquids and gases, etc. If all teachers of physics in our high schools were aware of the psychological possibilities of the subject and planned the course to encourage the development of these attitudes, ideas, habits, and skills, there would be many more girls and boys electing this work.

If the courses in *all* subjects in our secondary curriculum would be planned and conducted so that their content would encourage the above attitudes, ideas, physical habits, and skills, our public schools would turn out a far better product than they do at the present time. Our graduates would be better equipped in all ways to compete successfully in the post-war world.

FINGERTIP CONTROL FOR DENTAL DRILL ENGINE

A gadget to put dentists back on their feet has been invented by Dr. Maurice I. Blair, Chicago dentist. Dr. Blair's fingertip dental engine control, which changes the control of the dental engine from foot to hand, has just been given its first public display here.

The fingertip control which, Dr. Blair reports, is the first change in drill control in 30 years, is shockproof. It is manipulated simply by a sensitive electric button on the mirror handle, which is connected by aerial wire to the drill through a two-tube radio.

Dr. Blair reports that the inspiration for this improvement was the fact that he "got awfully tired of always standing on one foot." Dentists now use the foot control which makes it necessary for one foot to be constantly on the control.

Dr. Blair also points out that the foot control is an eyesore and a nuisance since most dentists' floors are waxed to a point of slipperiness and the foot control is always slipping out of reach, with the dentist sliding with it. Many a patient who has tripped over it will bless Dr. Blair for his invention.

In the two years that it took Dr. Blair to perfect his invention he ran across many disappointments when he found it impossible to use his original idea of placing the button directly on the drill. However, he hit upon the safe and happy idea of placing it in the mirror handle and it has proved to be successful.

After the end of the war, Dr. Blair's control will be manufactured so that other dentists may share in his invention.

PILOTS PROTECTED FROM SUNBURN

Transparent plastic which screens out severe sunburn ultraviolet rays is being used in aircraft construction to protect pilots from disabling sunburns. Aviators have often returned from long flights at high altitudes with severe burns because the rays pass through the plastic coverings now used.

TROUT RAISING AT HOME

B. F. STIFFLER
2101 Hanover St., Silver Springs, Maryland

The author has been an ardent fisherman for many years and in this avocation has found recreation and rest from the work in his profession. Fishing has taken him on many trips all over the country. He has, as any observant fisherman, studied streams and their surroundings with an analytical eye. He was impressed with the fact that natural, state and federal replacements of the fish population in the streams were not sufficient to offset the loss from catches by fishermen. The thought came to the writer that a profitable establishment might be set up for the raising of trout in a small stream where fishermen might come and gladly pay a small fee for the privilege to fish in the stream, or to raise fish for the market and thus increase the amount of a valuable food.

The first step in the undertaking was a survey of several streams outside the District of Columbia in Montgomery County, Maryland. This involved measurement of temperature, study of flow and purity of water, and the amount of shade during the course of a whole year. These are the main factors which will determine suitability of a stream for raising of trout. After it had been found that some of the streams in this locality were satisfactory for the raising of trout, a trip was made to the U. S. Bureau of Fisheries (now the Fish and Wildlife Service). Here the author was received enthusiastically, and during the intervening years was always given helpful cooperation in making analyses of the water and advice on proper feeding of fish. During the preliminary investigation considerable correspondence was carried on with men in various parts of the country who were already doing on a successful commercial scale what the author was planning to do in a small way. As a result of several years of study of the problems involved in the raising of trout the writer is convinced that it is not more difficult to raise trout than poultry, and the financial return is at least as great.

There are two approaches to the problem. One is to start with the eyed eggs and hatch them, the other is to get the newly hatched eggs (called fry) or even somewhat older fish (called fingerlings). In either case the preliminary steps are the same.

One must first locate a spring or springs which flow into a nearby stream or brook which has a constant flow of water. The water must be cool to cold, say a temperature range through the summer months of below 68 or 70 degrees F. The stream must, of course, have water the year around. All farm live-stock should be kept out of the stream. However, some inexpensive method could be arranged to take water from the streams to supply the necessary drinking water for live-stock on the farm. After the stream has passed the tests listed above the spring or springs feeding it should be selected to determine if the flow is constant and the volume of water sufficient for the number of eggs to be hatched. Good hatching temperatures range from 42 to 54 degrees F. A flow of one gallon of water per minute will hatch 3,000 eggs. The spring should be dammed up. This may be a simple earth dam or one constructed of cement and field stones. The spring water need be raised only to a height sufficient to make it flow in a steady stream through a piece of one-inch iron pipe into a common wash tub. A 6- to 8-foot section of iron pipe must be embedded near the top of the dam to discharge the water into the hatching trays. The intake end of this pipe should be covered with a piece of ordinary fly screen, the other end should be capped, and five three-sixteenth-inch holes should be drilled into the side of the pipe near the capped end. The hatching tub is constructed in the following manner: Into a number 3 common wash tub drill a hole about two inches below the upper edge, large enough to admit the capped end of the water pipe described before, and another for the drain which is located in the center of the bottom. A pipe five inches in length, fastened tightly to this hole, will keep the level of the water high enough to cover the pan with the edges turned up a half-inch on all sides to keep the eggs from sliding off. This pan is held in place by three brackets made from scrap iron and bent in such a manner that the tray holding the eggs is about an inch under the surface of the water at its highest point. These brackets hook on the top rim of the tub and are of different length so as to incline the egg tray with its deepest end near the incoming water spray.

Such an apparatus will accommodate 3,000 to 5,000 eggs. The eyed eggs may be obtained free of charge from either the state conservation department or from a federal hatchery. If they are to be obtained from a federal hatchery it will be necessary to obtain the endorsement of the request by your congressman.

The eggs should be ordered before the first of January, but the hatchery will place the shipping date.

Occasional inspection is necessary to make certain that a continuous flow of water is maintained and that dead eggs are removed (dead eggs are white and opaque). No further attention will be necessary until the eggs are hatched. The egg tray may then be removed and the fry can remain in the tub until they become small fingerlings or they may also (after the egg sac has been absorbed) be placed into rearing races or small ponds supplied with water from the spring. If the fingerlings are kept in the tub it becomes essential that a continuous flow of water be kept through the spray nozzle.

The newly hatched fish can be fed as soon as they are able to swim about freely. Hard boiled eggs beaten to cream with the addition of a little water, and also beef heart or liver ground very fine are excellent food for young fish. It is best to feed with a spoon before the spray of incoming water so that the food will be distributed evenly (a clean spoon is essential at all times). As the fish increase in size they may be fed with larger grains of food, and when near legal length, the particles should be coarse and the diet can be varied to include ground fresh fish or minnows, etc.

Beginning with fingerling length, trout should be separated into rearing races or pools of even-sized fish to keep the larger from eating the smaller ones. Rearing ponds can be supplied with water from a brook to take care of an expanding enterprise.

The author has had excellent success over the past six years with raising trout in Maryland and West Virginia. One year he set the hatching tubs and a fourteen-year-old boy (under careful supervision by the writer) carried the rest of the procedure through to completion and turned 95 per cent of the hatch as sturdy fingerlings into the brook on his father's farm. A sincere interest in a fish culture project will readily receive helpful cooperation from federal hatcheries and without doubt also from the officials of state hatcheries.

DEHYDRATORS

Dehydrators for home use, suitable for drying out vegetables and fruits, may be made at a small cost by using plans and instructions which are available without cost at any office of the U. S. Rural Electrification Administration. Non-critical material is used and house current furnishes the heat.

SELECTING AND ORGANIZING ACTIVITY-SUGGESTIONS FOR ELEMENTARY SCIENCE COURSES OF STUDY

WALTER A. THURBER
New York State Teachers College, Cortland, New York

INTRODUCTION—THE IMPORTANCE OF ACTIVITY-SUGGESTIONS

The activities which pupils carry out, both mentally and physically, determine what they learn, the attitudes they develop, and the habits of thinking they acquire. The function of schools is to set up situations which encourage desirable activities.

In the field of science we cannot expect teachers to discover independently a sufficient number of suitable suggestions for activities; they are neither adequately trained nor do they have the necessary time for such research. They need a great deal of help and that help is best given in the course of study which outlines the subject matter.

Teachers will usually accept the suggestions in courses of study in good faith; they have not the background to be critical. Therefore, the suggestions should be selected with utmost care, with an eye to scientific accuracy, to practicality, and to the ends accomplished. Each suggestion should be so worded as to allow quick and accurate interpretation.

Some may consider that the suggestions for activities occupy a subordinate position to the subject matter in an outline. If, however, we admit that the suggestions can and should determine much of the actual teaching, we realize that the suggestions are more than mere supplements to a course of study, they *are* the course of study.

The importance of teaching suggestions is not fully realized. Although considerable time has been devoted to the wise selection of subject matter, little has been given to the wise selection of suggestions for teaching the subject matter. Consequently, recent courses of study show little improvement in this respect when compared with those written fifty years ago, and some show a definite decline.

The following discussion incorporates some of the discoveries and some of the conclusions given in a report[1] of a study carried

[1] Thurber, Walter Arthur: "*A Study of the Activity-Suggestions in Courses of Study in Nature Study and Elementary Science.*" Unpublished thesis, Cornell University, 1941.

out at Cornell University. Over seventy outlines for Nature Study and Elementary Science were examined; of these twenty-seven were studied in detail, each suggestion being criticized from a number of standpoints. Thus, over 24,000 separate teaching suggestions came under careful scrutiny.

The twenty-seven outlines were chosen to be as representative as possible. The earliest is dated 1900, the latest is dated 1939; others represent periods between. Eleven of the outlines are for cities, the others are for states. Sixteen states in various sections of the country are represented.

The recommendations in this paper are largely negative in character; that is, they apply to practices which are better avoided. Years of experimentation, extensive publication of results in professional journals, and patient accumulation of successful methods are needed before general recommendations of a more positive character are possible. But there is need for the information given in this paper. When one begins work upon a course of study there are so many aspects which must be considered that without some guide, many phases will certainly be ignored. The function of this paper is to draw attention to some of these frequently neglected aspects.

The Problem of Subject-Matter Selection as Related to Suggested Activities

It is obvious that the study of deserts in eastern states and the study of seashore life in inland cities cannot be carried out with first-hand experiences. The same may be said for the study of things removed from pupils in time rather than space, things such as dinosaurs, and, in some localities, trolley cars. If first-hand experiences are the more desirable, it is essential that we be concerned with the proper selection of subject matter; the two phases are inseparable.

Some outlines seem to have been constructed with a view to both subject matter and accompanying activities. Among these, deserving special mention, are the Pennsylvania Outline (1932), the Berkeley Outline (1931) and the Cleveland Outline (1927).

On the other hand, it seems that the makers of certain recent outlines have concentrated upon the selection of subject matter without sufficient thought as to its relation to the activity-suggestions. As an example of an extreme case, the following topics have been selected from the outline of an eastern inland city:[2]

[2] Many outlines, strong in other ways, contain weaknesses which are quoted here. To avoid the injustice of stigmatizing a course of study because of a few weaknesses, these will not be named.

First Grade —The extent of the atmosphere
The extent of the land and water surfaces
The materials making up the earth
The winds of the earth
Early use of winds for sailboats and windmills
Methods of firebuilding among the Indians
Second Grade—The glacial period
Earthquakes as erosional agents
Formation of sedimentary, igneous and metamorphic rocks
Formation of fossils
Redwood trees
Seashore life (a full unit)
Third Grade —The nature of the sun (size, composition, distance)
The nature of the planets
The nature of the moon
The distances of the stars
The motions of the earth in space
The origin of the earth
The geological history of the world
Volcanoes
Mountain building
Early types of life on the earth
Cellular composition
Changes in forms of life on the earth
Coal-age forests, early amphibians, dinosaurs, early mammals, cave men
Possible causes for decline and extinction of dinosaurs
Discovery of fire
Beginnings of agricultural life
First domestication of animals
Early tools of man
Early sources of mechanical energy used by man
Fourth Grade—Conditions for life in the Arctic and the jungle
Motion of the moon in space
Early beliefs regarding motion of heavenly bodies
Galaxies, nebulae, the universe
Distances in the universe
Mass and gravitational forces
Lack of frictional forces in space
Effect of introduction of rabbits on an unnamed Pacific island
Introduction of the rat and the mongoose in the West Indies
Buffalo and pelicans
Fifth Grade —Earth's motions as causing seasonal change
Depths of the earth
Geological history of New York State from Precambrian times to the present
Molecular composition of matter
Atomic nature of matter
Molecular activity
Rare elements
Extent of the atmosphere
Government weather bureau
Deep sea diving

High altitude flying
Speed of light
Earth's magnetic poles

Sixth Grade —(Summarizing the work of the entire grade)
Theories about the origin of the earth
Geological changes on the earth since its origin
Early forms of life and subsequent evolution
Sociological and morphological evolution of man

Any effort to discover activities for use with the above topics reveals how much dependence must be placed upon books, pictures, charts, models and, undoubtedly, on teacher-telling. Such dependence and such emphasis are not in keeping with the philosophies of science teaching.

In the fields of geology, astronomy, and animal behavior, one notes the tendency to go far afield, to study the *causes* of hibernation and migration, and to study dinosaurs and spiral nebulae. This is not because there is any dearth of suitable first-hand experiences in these fields; the writer collected many suggestions during his study and has no doubt that many more are possible.

Some courses of study include simplified versions of the electronic and molecular theories. Following are some of the activities designed to teach these theories:

> Boil water to show the movement of the molecules. (Fifth Grade)
>
> Put a balloon over a bottle of air and heat. This blows up the balloon. This also shows that the molecules move farther apart and take up more space. (Fifth Grade)
>
> Illustrate how electricity flows in the circuit described above by lining up the class in a circle around the room giving each a piece of chalk. The pieces of chalk, or something similar, represent electrons. The "electrons" are to be passed from one pupil to another in the same direction. Each member of the class must always have one but not more than one electron at a time. The box must always contain the same number of pieces of chalk during the demonstration. While one is being taken out from one side, another is being replaced at the other side. If one member is taken out of the circle the movement of the electrons has to stop. (Fourth Grade)

The writer does not consider the above activities suitable and, until better are found, he does not recommend the teaching of the electronic and molecular theories in the grades.

The extent to which there should be study of things not of the immediate environment, is a matter deserving attention. Undoubtedly, there is a desirable balance between local and foreign materials, a balance that may vary somewhat for particular situations and from grade to grade, but which can be approximated in most courses of study.

It should be realized that time spent on things not of the environment of pupils is time denied to the giving of first-hand experiences. When the former are included, their value should be weighed against the value of possible first-hand experiences for which they are substituted.

It should also be remembered that experiences gained through books, pictures, and the like may not be properly appreciated and may even be misinterpreted, if there is not a suitable first-hand experience background. Before vicarious experiences are introduced, therefore, it is desirable to see that a suitable background has been established.

The Sequence of Activities

It is impossible to give here, because of space, one of the finest examples of sequence that was encountered. The reader is referred to the Pennsylvania Outline (1932) there to consider the activities dealing with insects.

In brief, the activities begin in the first grade with observations of butterflies and caterpillars and the raising of these in captivity. Emphasis is upon a common form, the Monarch. Activities are included for each season. In the second grade, the work with moths and butterflies is continued and extended; the lightning bug is introduced briefly for recognition. Identification of a few common insects is included in the work of the third grade and the habits of the grasshopper are studied in some detail. Thus throughout the grades, experiences are added, slowly at first, more rapidly as the pupils mature. By the end of the sixth grade, the pupils have a considerable acquaintance with common insects, a sound background for later study.

It is noteworthy that in the Pennsylvania Outline broad generalizations are carefully avoided. However, experiences are so chosen that pupils can make limited generalizations on occasion.

In a number of courses of study, however, subject-matter fields are concentrated in one or two grades, thus allowing no provision for gradual growth, for review, or for utilizing important out-of-school experiences. In extreme cases, the activities show no sequence whatever; they seem to be but devices for helping pupils memorize information given by the teacher.

This matter of sequence of activities deserves careful consideration. The activities carried out *are* the learning situations; sequence should be as evident in these as in the subject matter

itself. Even the most weakly trained teacher should be able to see that the activities suggested represent a gradual growth in experience background, and that one group of activities is a desirable prerequisite to the next. With such an understanding, teachers will realize the need for minimum essentials even as they so realize it in the field of mathematics.

There are those who may argue that science requires greater flexibility than other subjects. This may be true, but flexibility can be provided by numerous options, even while the minimum essentials are covered.

Short- and Long-Unit Organization

Some courses of study divide the work for each grade into a number of short units, or "topics" as they might be called. The second grade of the Cleveland (1927) outline, with its thirty-eight separate subjects, illustrates this practice.

September—Fall Flowers
Leaves of Common Trees
Seeds
October —Fruits
The Pear
Vegetables
The Crowning Glory of Autumn
November—The Horse
The Acorn
Preparing for Winter
Cocoons
December—Shells
Evergreen Trees
January —Reindeer
Nuts
Division of Time
Ice, Snow and Frost
Feeding Winter Birds
The Dog
February —The Sky in Daytime
The Sky at Night
Narcissus Bulbs
The Pigeon
March —The Weather Vane
Signs of Spring
The Pussy Willow
The Bluebird
April —Lima Beans
The Song Sparrow
Early Garden Flowers
The Red Headed Woodpecker
May —The Turtle
The Wren
The Ladybug
Fruit Trees

June —The Wood Thrush
Circus Animals
The White Daisy

Other courses of study base their organization upon a few long units. The Maryland (1933) outline suggests only six units for the second grade as follows:

Unit 1. Where plants and animals live
2. How birds spend their time
3. How seasonal changes affect living creatures
4. Where heat comes from and what it does
5. What the earth is like
6. How animals and plants supply us with food

After examining a number of courses of study, and comparing the possibilities of each organization, the writer has come to certain conclusions regarding the desirability of short units as compared with long units.

Short-unit organization is better adapted to seasonal arrangement. Many of the phenomena of our environment vary with the seasons. Short units may be arranged to take advantage of seasonal material; long units confine a teacher to a single or, at most, two seasons. Thus, several short units on birds allow study of birds in all seasons.

From the standpoint of flexibility, the short-topic organization seems superior. A teacher may change the order of the topics, may eliminate one or substitute one, without seriously affecting the program. There are times when teachers do well to take advantage of local or temporary features of the environment. But to interfere with a long unit is less simple.

Grade placement is simpler with short-unit organization. In most subject-matter divisions there are activities suitable for early grades and activities suitable for advanced grades. Short topics may be distributed through the grades to take advantage of the abilities of pupils. Long units, concentrated in a single grade, must use activities whether they are suitable, too elementary or too advanced, if a suitable background is to be developed.

Long units demand a long attention span. If six units per grade are suggested, a single unit requires, roughly, six weeks. Six weeks is a long time to concentrate upon one subject.

Short units provide a richer background. Planned experiences in an early grade give meaning to the incidental experiences pupils have later. These new, enriched experiences then give meaning to planned experiences in a later grade. Thus there is

a gradual interaction of planned and incidental experiences. A single long unit cannot provide such interaction.

Short-unit organization allows a natural reconsideration of much that has been learned in previous grades. This is a desirable type of review. With the long-unit organization a great deal of material is crowded into a single brief period and is then permanently dropped.

Still another fault that attends the use of long units is the tendency to emphasize principles. Thus, if a unit is labeled "Light" the emphasis is upon such things as "Light travels in straight lines." But with small, separate units, we find the study revolving about such things as "The Rainbow," "The Magnifying Glass," and "Mirrors." The danger of emphasis upon principles lies in the tendency to generalize before sufficient data have been accumulated.

The Number and Distribution of Activity-Suggestions

The numbers of activity-suggestions vary markedly in various courses of study. Several outlines contain none. The maximum number occurs in the St. Louis (1926) Outline with a total of 2746; New York (1939) contains 2125. Exact numbers have little significance because some suggestions are simple, others elaborate, but they do indicate something of the richness of help given to the teachers.

Several courses of study include only a bare outline of subject matter with no teaching suggestions whatever. A few expand one or two illustrative units to include teaching suggestions, leaving the other units to be developed by the individual teachers.

The United States Office of Education reports[3] that in junior and senior high schools, detailed courses of study receive more use. One might expect the same in elementary schools where teachers are less specialized.

The writer's own experience has impressed him with the urgent need of elementary teachers for help in their science teaching. They need a multitude of practical ideas for teaching every unit; merely expanding one or two as samples is not enough.

Whatever the optimum number of suggestions is, and the writer knows of no attempt to determine it, the padding of a course of study with inferior suggestions can do little good, and

[3] United States Department of the Interior, Office of Education: "*Instruction in Science*," Bulletin 1932, No. 17, Monograph No. 22. 1932

harm might even result if the teacher becomes confused and discouraged. Some outlines might be considerably improved merely by *eliminating* some of the inferior suggestions.

There is little uniformity of practice in the grade distribution of activity-suggestions. Seven outlines examined show a marked and unexplained decrease as the fifth and sixth grades are reached; two show an increase; some are irregular. There may be little significance to grade distribution of activity-suggestions, yet the marked slighting of one or two grades is puzzling.

The Problem of Describing Suggested Activities

Not infrequently, suggestions for activities are described in terms so indefinite as to fail to make clear the intent of the writers. Not only are procedures poorly described but sometimes the very purpose of an activity is uncertain. A few examples serve for illustration:

"Develop the use of a flower's petals, its colors, scent, and how it makes the insect pay for its meal."
Bring out the protective feature of its (a lizard's) tail.
Cultivate an attitude of protection on their (the pupils') part.
Note rapidity with which flies increase.
Create in the child's mind a reverence for the unfolding of new life.
Call attention to the fact that bees are harmless when left alone.
Lead the children to want to protect the toad.

Indefinite teaching suggestions are often introduced by some of the following phrases:

Call attention to the fact that .....
Note that .....
Study .....
Teach that .....
Learn that .....
Show that .....
Lead the children to discover that .....
Lead the children to notice that .....
Lead the children to want to .....
Emphasize the importance of .....
Stress .....
Point out .....
Encourage pupils to .....
Develop the facts about .....
Bring out the fact that .....

Properly trained teachers may be able to utilize generalized suggestions such as those given above, but it is doubtful whether the majority of teachers can do so. The untrained teacher certainly needs specific, clearly-worded directions.

The writer became particularly impressed with this while

helping a group of in-service teachers follow the directions for demonstrating an electric fuse. Because the width of the tin foil used was not given, nearly every teacher failed in her efforts. Without an adequate science background, few teachers can interpret and improvise as the science-trained teacher can.

In the New York (1939) Outline, there are several pages of photographs and diagrams. It is probable that these pages are worth many pages of print and that they completely justify their cost.

One would expect that in the interests of safety, dangerous activities would be described with a plentitude of cautions. Such is not always the case; activities involving dry ice, bichloride of mercury, gasoline explosions, hydrogen combustion and poisonous fungi were suggested without any warnings whatever.

Sometimes the failure to describe activities adequately may be ascribed to failure to try out the activities before hand. Sometimes one only suspects this as a cause, at other times one is certain, as in the following:

> Estimate the amount of food consumed by a bat outdoors during an evening.
>
> Bring a dog to school. Blindfold him and see if he will smell his way to a bone across the room.
>
> Note what happens to rocks when they freeze.
>
> Heat pieces of limestone until the CO_2 is given off.
>
> If frost does not form on the window pane, allow a large piece of glass to become coated with frost outdoors.
>
> Do a trick known as "Pepper's Ghost." This is done by setting a mirror at an angle on a table in such a way that you can see a burning candle that is set near the edge of the table. Place a tumbler of water in front of the mirror in such a way that the candle appears to be burning inside the tumbler of water.

There is no excuse for the above nonsense. Such suggestions and many others of a similar nature are worse than useless; teachers attribute any failures to their own inadequate background and thus add to their feeling of inferiority. Those who cannot try out suggestions for activities ought not to be writing courses of study.

Impractical Suggestions

Mention has already been made of suggestions that are impossible or nearly impossible to carry out, and it was stated that these suggestions could be avoided if the makers of courses of study were to try them out in advance. Various types of such suggestions can be isolated. There are naïvely ridiculous sug-

gestions which call for collecting or for learning *all* of something:

Bring in all forms of animal life.
Recognize all the clovers and their relatives, or all of the composite family.
Catch as many different kinds of insects as you can and learn their names.

There are suggestions for doing things that are apt to be inconclusive or apt to give dissatisfaction because of certain natural limitations:

Dit out a mole to observe it.
Dig a hole in a field. How far can you dig before reaching rock? (A First Grade activity)

Other suggestions call for activities for which the human constitution is unfitted:

Notice the locomotion of moths and butterflies and try to imitate.
Learn to judge the temperature of the room and verify.

Some suggestions evidence an ignorance of the slowness of geologic processes:

Note what happens to rocks when they freeze.
Test the lasting qualities of building stones by watching the effect of water and frost.

Certain suggestions call for the use of apparatus which would ordinarily be beyond the reach of most elementary school teachers:

Heat the end of a glass rod and insert a two-inch piece of platinum wire.
Heat pieces of limestone until the CO_2 is driven off and CaO is left.

The Suggestions for Data-Collection Activities

In the courses of study which were examined the emphasis was upon data collection, or, put differently, upon establishing an experience background. It is gratifying to note that the majority of the suggested activities involved direct observation although there was considerable variation in the proportion of vicarious to first-hand experiences, Michigan (1933) suggesting 19 of the former to 594 of the latter, while Massachusetts (1931) offered 244 to 372, respectively.

The grade distribution of first-hand and vicarious experience suggestions is a matter of importance but one to which little or no study has been given. Study of present practices reveals only an irregular distribution that suggests no forethought. New York (1939) and Pennsylvania (1932), it is true, do increase the number of references to books, pictures and the like in the upper

grades, but one course of study suggests the maximum number of such references for the first grade.

It does not seem that the number of first-hand experiences should taper off in the upper grades; certainly older pupils need such experiences as much as ever. On the other hand, most will agree that a certain number of vicarious experiences should be introduced. The most that will be said in this discussion is that it seems best to minimize references to books, pictures and the like in the lower grades.

One regrettable practice regarding data-collection suggestions was encountered. This was the habit of suggesting that data be collected without giving any clue as to where the required data could be found. In eighteen of the twenty-seven outlines analyzed, 10% or more of the total suggestions were of this type, and in three of these, the proportion was over half.

One may not assume that untrained teachers will know where to find data. They may depend upon books when first-hand experiences are possible. They may attempt to *tell* pupils what they believe to be correct information. At best, they will only ignore the suggestions.

A distinct weakness found in many courses of study may be attributed to the failure to give sources of information. In every course of study there are numbers of questions which would be difficult if not impossible for pupils to answer correctly. For instance, no course of study failed to ask some version of the question, "Why do birds fly south in winter?" a question which bothers many ornithologists. Similar questions are typified by the following:

Why do animals hibernate?
Why do evergreens keep green in winter?
Would anything grow if the sun did not shine?
Why does the toad have the color of the earth?
What guides bees to flowers that contain nectar?
What would happen if there were no birds to destroy the insects?
Do all animals have parents?
Why does the father bird do all the singing?
Can we see all of the universe with even the biggest telescopes?

Utterly absurd questions would never be included were the makers of courses of study to tell specifically where the answers could be found.

The Suggestions for Data-Utilization Activities

Makers of courses of study have not fully realized the great possibilities of activities which utilize data collected by pupils.

Examination of one or two outlines does not make the problem evident; only the composite of a large number of outlines called the matter to the writer's attention.

Although in existing outlines from 10% to 25% of the total activities are of this type, the suggestions themselves are weak and generally inadequate. Directions are scant, sometimes only a hint is given. In most cases the collection of data is tacitly implied in the directions for their use, with all the attendant dangers that have been mentioned before about failure to give the source of data.

Activities which encourage the pupils to create and to express themselves are among those most frequently given. Unfortunately these are rarely specific. In one outline the following sequence was repeated again and again for different topics with but slight variations—this topic happened to deal with caterpillars:

Drawing them on leaves
Modeling in clay
Cutting free hand
Singing songs
Making booklets

Pictures, stories, poems, models, charts, posters, are but some of the things which pupils can create. To say, "Make a picture," however, is not enough. Directions and examples are needed to start the pupils thinking along desired lines.

Much of the work just mentioned falls under the heading of "art," and usually its scientific flavor is mild indeed. There again is another problem for the makers of courses of study, to show teachers how such work can be used to instill correct scientific concepts.

Summarization activities are essential. Many creative activities perform their best service in this capacity, as when posters are used to summarize health units and booklets to summarize the study of an industry.

Discussion activities seem desirable, although good discussions are difficult to conduct, especially with large classes. The usual suggestions are too general, as with the following:

Discuss the different breeds of dogs in the homes of different pupils.
Discuss the method of distributing gas to homes.

Although labeled discussion, the general purpose of the above seems more to gather information from the pupils than to stimulate true discussion. The following admits of discussion but un-

fortunately there is no attempt to discover whether the pupils have an adequate background for discussing the subject:

Discuss the possibilities of life on Pluto and Mercury.

Discussion activities should be chosen and worked up with care. They best follow a period of data-collection so that all pupils have developed an adequate background for discussion. They may well be used to criticize certain sources of data, such as pictures of dinosaur reconstructions, and to consider some of the factors which might influence an experiment. It is most essential that the teachers be given some indication of the direction the discussion is to take if the activity is to have any predetermined value.

Early courses of study use a number of games and other play activities for the purpose of drill. Later courses of study rarely use them. The reasons for such a change in philosophy have not been given. Whatever they are the writer believes that there are certain play activities which deserve consideration before they are eliminated entirely.

The Use of Books, Pictures and Similar Authorities

The apparent lack of planning in the distribution of vicarious experiences has already been discussed and a few recommendations have been made. The need for developing a more critical attitude towards books, pictures and the like will now be considered.

Many educators have expressed concern about the inaccuracies that creep into books. Anyone with a moderate background can hardly suppress a chuckle when going through texts and references designed for children. Despite all this, the writer found not one word designed to help teachers develop in pupils a critical attitude towards books.

The same may be said regarding references to pictures, charts and the like. Without question, these sources vary in authoritative value. If pupils are too young to appreciate the gradations they should not be encouraged to use such sources.

Special research is needed to discover good methods and proper grade placement for attempts to develop in pupils a proper critical attitude. In the meantime it seems that many good opportunities are being neglected.

There are numerous books and stories in which animals speak, dress and think like humans. Pupils early recognize that animals do not speak and dress like man; they sometimes never learn

that animals do not think like man. Teachers need help in starting discussions designed to make pupils conscious of occasions when animals act unthinkingly.

Another example of neglect is illustrated by this quotation, "Study pictures of restorations of coal age scenes." What a wonderful opportunity for a consideration of the means by which data for the restoration were assembled, and the possible errors in the pictures: Instead, we find the following:

"Find pictures of animals that lived at various times in the past. Decide what the climate must have been when these animals lived."

The Suggestions for Experiments

All makers of courses of study do not interpret the term "experiment" in the same way. Some use the stricter meaning in which an experiment involves closely controlled situations. Others think of any manipulation of materials as being an experiment. One course of study goes so far as to label as experiments certain demonstrations in which pupils are led to preformulated conclusions through adroit questioning.

The true scientific experiment, which involves controlled situations, is usually considered as the keystone of the scientific method. At first thought, it might seem that any course in science should offer considerable practice with this method of data collection. However, for the elementary school, there is the problem of whether young pupils can appreciate the niceties of the controlled experiment and, if so, at what age they begin to do so.

Analysis of courses of study shows that there is little plan for introducing controlled experiments to the pupils. One outline offers more suggestions for experiments in the first two grades than in the others combined; many other outlines show a similar but less marked tendency. Only New York (1939) and St. Louis (1926) suggest an increasing number of experiments for the upper grades.

In general, there are but few suggestions for experiments offered. Glens Falls (1936) includes a maximum of 7% of the total suggestions; some outlines offer no more than one a year.

What suggestions there are do not seem to be the result of careful study; some completely ignore important factors:

> Find out if milk is important in the diet by experimenting with white rats—feeding one milk and one coffee. Weigh and observe.
>
> Take three pots of seeds, provide them with soil, moisture and air, and

put one outdoors, one in the house on the radiator, and the third on a shelf in the window. Record the temperatures of each place daily and let the plants grow a week.

None of the courses of study attempted to inform the teachers about factors which might possibly affect an experiment. Neither was there any effort to help teachers develop in themselves and in pupils a critical attitude regarding experiments.

The study revealed that there is a pressing need for research into the problem of the best time and the best means of introducing pupils to controlled experiments. There is also a great need for suitable experiments to be carried out in the elementary school if such are to be used there.

The failure of courses of study to help in the development of a critical attitude is a depressing aspect of our present practices. It seems that our courses of study represent one of the best mediums for such effort and that this should be one of their chief functions.

The Suggestions for Analogies

Courses of study frequently call for the setting up of analogous situations. These range in complexity from the hatching of frog eggs in aquariums to the burning of ammonium dichromate in plaster-of-paris volcanoes. Nevertheless there was discovered no effort to make teachers and pupils conscious that they were dealing with analogous situations and there was discovered no warning of the dangers of reasoning thereupon.

It is possible that many people are not themselves conscious of analogous situations; the venerable demonstration of phases of the moon in which a ball and a light source is used, has the sanction of generations. But in all analogies there are one or more factors differing from the situations the analogies are intended to represent. It is in these differing factors that misconceptions arise.

Some analogies cannot help but give false impressions. Burning ammonium dichromate in a plaster-of-paris volcano implies that real volcanoes burn. Models of the solar system, unless made to scale and placed at proper relative distances, give erroneous concepts of sizes and distances.

Despite the fact that analogies seem to demand a more mature mind if they are to be used safely, most of the outlines offered more suggestions for analogies in the lower grades than in the upper grades.

Analogies are much used to influence opinion. Pupils need contact with them; they should become conscious of them and should learn to evaluate them. However, it is probable that pupils need to be introduced to analogies cautiously, using at first only those for which the pupils have a suitable background for criticism. Without question, courses of study should contain help for the teachers who are to develop the proper attitude toward analogies in the pupils.

The Suggestions for Individualized Activities

There is almost no provision for individualized activity in the courses of study that were examined. By including all suggestions for night sky-study, which can generally be considered as home problems, less than 3% of the total suggestions in twenty-two outlines were for individualized activities. In twenty-five outlines the numbers ranged from none to forty suggestions, or, on the average, less than seven per grade. In addition, there was no help for teachers in improvising and administering this type of activity.

Thus we find another vast field offering possibilities for study. We need suggestions. We need techniques of administration, all of which have been proven by trial. Otherwise, important values of science education are not utilized.

The Suggestions for Considering Hypothetic Situations

Apparently some educators believe that the hypothetical situation presents a bone on which developing minds can cut their teeth. We find the following:

What would happen if flycatchers came before robins?
If you lived always in a dark room, what effect would it have on your complexion, your appetite, your energy, your health?
Write an imaginary story with illustrations of what the effect would be in B———— if all the birds were caught, shot, or trapped.
Imagine what the earth might have been like before there were any large plants and animals.
What would happen if it never rained?
How cold do you think our earth would be with no sunshine?
Would anything grow if the sun did not shine?

Perhaps these activities have value. However, it seems certain that the pupils can only guess and rarely have an opportunity to check their guesses, and that even their guesses are based upon a wholly insufficient background. If problems of this sort are to be included, why not let them be of a simple nature?

Scientific Exactness

The writer does not believe that in elementary science one need quibble over minute details. Nevertheless, a course of study is referred to by teachers as a final source of authority; it should justify this trust. Errors of fact should be avoided conscientiously.

Courses of study are apt to contain undesirable suggestions ranging from absurd inaccuracies to inconsequential misuse of terminology. Other suggestions, accurate in final analysis, are liable to misinterpretation.

The subject-matter fields in which inaccuracies occur are many, and it is impractical to consider each in detail. A selection of some of the errors are given below:

Try to hold a toad; feel his slimy skin.
Begin a collection of rocks. Observe that some are formed by pressure, some by fire and some by change.
Show how the contraction by the heat of the sun and the expansion by the cold and the frost have cracked the exposed rocks into many smaller pieces.
Determine how an electric fan cools the air.
Tell the children that the horns of the cow are gradually disappearing.
Why are insects necessary for pollination?

One example of incorrect terminology is worthy of discussion. The term, "steam," loosely used in everyday language, is ludicrously defined in courses of study:

Boil some water in a teakettle. Watch the steam, like little clouds, float away from the teakettle.
When water boils in a teakettle can you see the steam? No, dry steam is a gas just as water vapor is a gas, but moist steam consists of tiny drops of water.
Clouds and fogs consist of water vapor that has partly condensed.
Boil water and bring a cool plate into contact with the steam. Observe the drops of water vapor.
Heat water in a teakettle until steam pours from spout. Discriminate between the vapor and steam as they come from the spout. Steam is water that is partly condensed.

It is unfortunate that errors should ever creep into a course of study. An otherwise good course of study is immediately stigmatized by any error, whether serious or trivial.

Errors can be avoided by calling in a staff of reviewers who are competent in their fields and who will be conscientious in their work. The makers of courses of study cannot trust themselves, because no person suspects that he is wrong until some circumstance calls attention to his error.

Teleology and Animistic Interpretations

To many in science education teleology is an abhorrence. Others, especially in the elementary field, have owed their professional and financial successes to it. But while many condemn it, few have upheld it, and so the premise will be made here that teleology is generally undesirable. This assumption, like so many in education, has no scientific backing. It is a matter of opinion.

Teleology is difficult to avoid. Even those who sputter the most about the failing in others, slip themselves on occasion. Perhaps the answer is that we should all strive to develop a consciousness of teleology, to ignore the lapses of others when no harm is done, but to protest immediately, when conclusions seem colored by such interpretations.

It is possible that a well-planned science program can develop the consciousness of teleology in elementary pupils. They learn at an early age that animals do not talk or dress as humans do. Under guidance they might learn that animals do not think as we do. The development of this portion of the program well deserves consideration.

Of the many suggestions allowing of teleological interpretation a large portion deal with "preparation for winter."

What preparation for fall do trees make?
Discuss how grass prepares for winter by producing seeds?
How do ants prepare for winter?
"Old Mother Nature" comes in for some attention.
Observe how Mother Nature scatters her seeds.
Stress how nature equipped the owl for its work on the night shift.

These suggestions may not be overly harmful although they do imply that there is forethought on the part of living things or "Nature," a belief that is unsupported by satisfactory evidence.

More pernicious are the definitely animistic interpretations which give to plants, animals, and even inanimate objects, the mental characteristics of humans.

Pour some water on the dry soil and see if the plant will become well and happy again.
Find sleeping dandelions.
Since they (mushrooms) cannot make their own food, they act like robbers, because they take food that other plants make.
Stress the ant's devotion to aphids or ants' cows.
Observe the lazy cowbird, the parasite among birds.
Put a red line under the right word.
Rabbits are—brave, afraid

Answer yes or no
1. English sparrows always have good manners.
2. English sparrows are brave.
3. English sparrows are smart.

Is ice always friendly?

Why do you suppose raindrops are in such a hurry to reach the ground?

Animistic interpretations of natural phenomena are apt to awaken unjustified prejudices; snakes become wicked, foxes cruel, rabbits harmless, cowbirds undesirable parasites. The goals of science education can never be reached if pupils emerge from schools with this state of mind.

Generalizing upon Insufficient Data

Generalizing upon insufficient data is one of the cardinal sins of science. It is to be expected that courses of study would make a determined effort to stamp out the evil.

Actually, there are a few outlines which warn against the act in their somewhat wordy introductions; beyond this none go. Worse, there are suggested activities which *encourage* generalizing upon insufficient data:

How are the teeth of animals fitted to the kind of food they eat?

Collect pictures of different animals and divide them into two groups, plant-eating and flesh-eating animals.

Why do fish need scales?

Call attention to the moth's habit of flying at night.

Do animals need exercise?

Do all animals have parents?

Why do young animals need their mother's care?

Why are insects necessary for pollination?

Which way does a root always grow, up or down?

Show that heat makes substances dissolve faster by placing equal amounts of sugar in equal amounts of hot or cold water.

Where glaciers exist on the earth today are they advancing or receding? Does this indicate that our climate is becoming warmer or colder?

It seems reasonable to expect that courses of study would not only avoid such suggestions as those quoted but that they would caution teachers against expecting too much when even minor generalizations are called for. For instance, if the interesting experiment regarding the effect of temperature on the dissolving of sugar is suggested, teachers should be warned ***not*** to let the pupils carry their generalizations beyond the effect on sugar.

Summary

Although courses of study usually list as one of their primary goals the development of scientific attitude, in practice they

often fail to maintain such an attitude themselves and they fail to develop the attitude in teachers and pupils. To recapitulate:

1. There are errors of fact.
2. Incorrect terminology is sometimes used.
3. Certain activities admit of teleological and animistic interpretations.
4. Generalizing upon insufficient data is occasionally encouraged.
5. Guessing is encouraged when there is no opportunity to check the guesses.
6. Experiments which fail to control, or which fail to consider, important factors are suggested.
7. There is no attempt to develop in teachers and pupils a realization of the variable trustworthiness of different sources of data.
8. There is no attempt to develop in teachers and pupils a consciousness of analogies and the limitations of analogies.
9. Pupils and teachers are not given an understanding of the experimental method.

Courses of study do not always recognize the limitations of pupils and provide for their gradual development, in other words, they sometimes ignore certain fundamentals of educational psychology:

1. Material not from the immediate environment of the pupils is frequently stressed in even the early grades.
2. In many courses of study there is no visible effort to develop a suitable experience background for the pupils before introducing vicarious experiences.
3. Some courses of study show as great a dependence upon books and similar authorities in the lower grades as in the upper grades.
4. Some courses of study introduce as many or more controlled experiments in lower grades as in upper grades.
5. Analogous situations are sometimes used as much in lower grades as in upper grades.
6. There is little effort to encourage pupils to take their school experiences home for relation to out-of-school experiences.
7. A sequential development of experience background is not always in evidence.
8. The use of a few long units rather than several short units discourages if it does not prevent the interaction of incidental and planned experiences.

Courses of study are not always practical in the suggestions which they include:

1. Suggestions are not always clearly worded as to method and purpose.
2. Pictures and diagrams are infrequently used to supplement the printed directions.
3. Dangerous activities are suggested without suitable warnings.
4. Suggestions are made for activities which are difficult if not impossible to carry out.
5. There are included questions which would be difficult or impossible for pupils to answer.
6. Many suggestions for data-collection fail to mention possible sources for the data.

7. Long units discourage the use of seasonal materials and other materials of a temporary value.
8. Teachers are given few suggestions as to techniques of administering the various types of activities.

Thus we see that there is much room for improvement of existing practices in course of study making. There is need for much experimentation and research by those who have an adequate scientific and experience background. Courses of study will never attain their maximum value until such improvement has been attained.

COURSES OF STUDY INVESTIGATED IN DETAIL

Berkeley Public Schools: *Nature Study*, Course of Study Monograph. Berkeley, California, 1931.

Detroit Public Schools: *Course in Nature Study for Grades One and Two.* Detroit, Michigan, 1927.

Cleveland Public Schools: *Tentative Outline Manual—Elementary Science.* Cleveland, Ohio, 1927.

Florida State Department of Public Instruction: *The Course of Study for Florida Elementary Schools.* Tallahassee, Florida, 1934.

Glens Falls (N. Y.) Public Schools: *Elementary School Science.* Glens Falls, New York. Mimeographed, 1936.

Horace Mann School: *Tentative Course of Study in Elementary Science.* Bureau of Publications, Teachers College, Columbia University, New York City, 1927.

Iowa Department of Public Instruction: *Course of Study for Elementary Schools.* Des Moines, Iowa, 1928.

Maryland State Department of Education: *Science in the Elementary School.* Baltimore, Maryland, 1933.

Massachusetts Department of Education: *A Course of Study in Science for Elementary Schools.* Boston, Massachusetts, 1931.

Michigan Department of Public Instruction: *Nature Study and Elementary Science.* Lansing, Michigan, Mimeographed, 1933.

Minnesota Department of Public Instruction: *Course in Nature-Study for Elementary Grades of Minnesota Public Schools.* St. Paul, Minn. 1909.

Minnesota State Department of Education: *Curriculum for Elementary Schools.* St. Paul, Minnesota, 1923.

Missouri Department of Public Schools: *Courses of Study for Elementary Grades.* Jefferson City, Missouri, 1937.

Missouri State Department of Education: *Course of Study for Elementary Schools.* Jefferson City, Missouri, 1929.

Montana State Department of Public Instruction: *A Tentative Outline for a Course in Nature Study to Be Used in the Elementary Schools of Montana.* Helena, Montana, 1927.

New Jersey State Department of Public Instruction: *The Teaching of Nature Study and Elementary Science.* Trenton, New Jersey, 1929.

New York State Education Department: *Elementary School Science.* University of the State of New York Bulletin No. 1157. Albany, New York, 1939.

Pennsylvania Department of Agriculture: *A Course in Nature Study for Use in the Public Schools.* Bulletin No. 63. Harrisburg, Pa. 1900.

Pennsylvania Department of Public Instruction: *Course of Study in Science,* Vols. I and II. Harrisburg, Pennsylvania, 1932.

Pittsburgh Board of Public Education: *Course of Study in Nature Study and Elementary Science.* Pittsburgh, Pa. 1928.
Springfield (Massachusetts) Public Schools: *Nature Study in the Public Schools.* Springfield, Mass. 1911.
Springfield (Massachusetts) Public Schools: *Nature Study in the Public Schools.* Springfield, Mass. 1939.
St. Louis (Missouri) Public Schools: *Science for the Kindergarten and Grades I–VI.* St. Louis, Missouri, 1926.
Toledo (Ohio) Public Schools: *Courses of Study in Nature Study.* Toledo, Ohio, 1934.
Tulsa (Oklahoma) Public Schools: *Elementary Science.* Mimeographed Outline, Tulsa, Oklahoma, 1931.
Utah State Department of Public Instruction: *Utah Course of Study for Elementary Schools.* Salt Lake City, Utah, 1923.
Wyoming State Department of Education: *Suggestive Courses of Study in the Rural Schools of Wyoming,* Cheyenne, Wyoming. No date.

A TEXTBOOK SERIES FOR PRE-FLIGHT TRAINING COURSES

The McGraw-Hill Company has published a group of twelve short texts in a new series entitled "Flight Preparation Training Series." This outstanding new series has been produced under the supervision of the Training Division, Bureau of Aeronautics, U. S. Navy.

This series of texts has been prepared to meet the special needs of intensified training courses for pilots in wartime. Under war conditions the need for a thorough understanding of basic science and navigation by pilots has become acute, while the time available for study is reduced to a minimum. These texts, therefore, embody enough theory and background to provide the student with an intelligent understanding of science and navigational principles but omit all duplicating and non-essential matter.

The books are written in somewhat light and interesting style, and in some cases an unorthodox approach and treatment have been deliberately adopted. Experience has proved their effectiveness in arousing interest and developing an inquisitive and curious frame of mind in the students. While each text is complete in itself, the instructional value of the group as a whole will be enhanced by the use of sound motion pictures, slide films, and other teaching aids that have been especially prepared for use with the Series.

The twelve books range from 100 to 250 pages each. There are five basic, pocket-size texts entitled *Mathematics for Pilots, Physics Manual for Pilots, Principles of Flying, Operation of Aircraft Engines, Aerology for Pilots,* and seven volumes in larger formation. *Air Navigation* including Part I—Introduction to Earth, Part II—Introduction to Navigation, Part III—Dead Reckoning and Lines of Position, Part IV—Navigation Instruments, Part V—Relative Movement, Part VI—Contact Flying, Part VII—Nautical Astronomy and Celestial Navigation.

In the U. S. Navy's Aviation Training Program this Series of books constitutes the intensified, three-month flight preparatory Ground School course. As such, the Series as a whole represents what is probably the first carefully planned and thoroughly integrated set of texts that has been available for the complete pre-flight course based on Service standards. At the same time, the Series should be ideal for a full year high school course at the eleventh or twelfth grade level, or for more intensified courses at the intermediate or college level.

WHAT LABORATORY EQUIPMENT FOR ELEMENTARY AND HIGH SCHOOL MATHEMATICS?

F. H. GORMAN
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One of the fundamental elements of the program of instruction in elementary and high school mathematics is that of assisting the pupil to develop clear objective concepts of the useful units of measure and the instruments of business. Moreover, it must provide him with basic experience in using them.[1] The underlying question is: How is the school properly to assist the child to develop these concepts and give him the necessary basic experience? Certainly one essential is the observation and use of the actual instruments by the pupils. Instruction in this element of mathematics therefore in large part should be of the work-shop or laboratory type.

What pieces of equipment should be available for teacher and pupil use in objectifying this area of mathematics? The leaders of thought in the teaching of mathematics are quite naturally considered the ones to offer the best advice regarding such matters. Heretofore they have not definitely expressed themselves on the question. It is evident that the majority of them have assumed that most teachers are using objectifying equipment freely and properly. The fact is that relatively few teachers are in position to do this effectively.

Comparatively few schools possess or have adequate access to even the commonest measuring equipment. Even more serious is the widespread unfamiliarity of teachers with the proper knowledge and use of such equipment. Furthermore, there is little organized information available on effective techniques and procedures in teaching the units of measure and the instruments of business activities, and in providing the basis experience. Of the number of books written since 1935 on the teaching of mathematics in the elementary and secondary schools, only two were found to contain any suggestions on the use of actual tools of measure and of business operations.

PURPOSE AND PROCEDURE OF THIS INVESTIGATION

This investigation was conducted for the purpose of obtaining

[1] This point is well discussed by Guy M. Wilson, et al., in *Teaching the New Arithmetic*, pp. 241–242.

the opinions of a number of authorities on the teaching of mathematics relative to this question: What instruments of measure and of business practice and what other equipment should be available for use in teaching mathematics in the elementary and secondary schools? A survey of the literature revealed no discussion of this matter within the last three decades.

TABLE I. ITEMS OF EQUIPMENT FOR USE IN THE TEACHING OF MATHEMATICS IN THE ELEMENTARY SCHOOL, JUNIOR HIGH SCHOOL, AND SENIOR HIGH SCHOOL

Name of article	
1. Yardsticks	38. Sets of practice cards for basic facts of four fundamentals
2. 12-inch rulers	39. Number games
3. Steel or fabric tape (50 feet)	40. Chart of fractional relationships
4. Meter sticks	41. Chart of aliquot parts
5. Set of square measures	42. Slide rules (practice type)
6. Set of cubic measures (U. S. Standard)	43. Demonstration slide rule
7. Set of cubic measures (metric)	44. Crossruled blackboard section
8. Geometric solids	45. Trigonometric tables
9. Blackboard compasses	46. Pantograph
10. Desk compasses	47. Insurance policy forms of all kinds
11. Individual protractors	48. Insurance rate books
12. Blackboard protractors	49. Interest tables
13. Map of Federal Survey	50. Tax assessment forms
14. Road maps	51. Deeds and abstracts
15. Set of intersecting planes	52. Rent contract forms
16. Surveyor's transit and rod	53. Bank note forms
17. Plane board and compass	54. Checks
18. Carpenter's square	55. Deposit slips
19. Carpenter's level	56. Deposit books
20. Architect's scale	57. Bank statement of account
21. Set of blueprints	58. Cashier's checks
22. Drawing board, T-square, and triangles	59. Bank draft
23. Drawing instruments	60. Letter of credit
24. Lumber calculator	61. Sight draft
25. Wire for forming models	62. Time deposit slips
26. Scales and weights (avoirdupois)	63. Stock certificates
27. Scales and weights (metric)	64. Bonds
28. Dry measures (U. S. Standard)	65. Invoices
29. Dry measures (metric)	66. Post Office money orders
30. Liquid measures (U. S. Standard)	67. Express money orders
31. Liquid measures (metric)	68. Telegraph money orders
32. Household measures	69. Parcel post rate tables
33. Water meter dial	70. Freight rate tables
34. Gas meter dial	71. Express rate tables
35. Electric meter dial	72. Railroad timetables
36. Clock	73. Bus timetables
37. Stopwatch	74. Work table and chairs
	75. Scissors

A list of seventy-five items of equipment was sent to forty-six recognized authorities on the teaching of elementary and second-

TABLE II. ITEMS OF EQUIPMENT CONSIDERED BY THE MAJORITY OF THIRTY-TWO AUTHORITIES IN THE TEACHING OF MATHEMATICS AS HIGHLY IMPORTANT OR DESIRABLE FOR USE IN ELEMENTARY SCHOOL
(Grades 1 to 6)

Item	Considered highly important by	Considered desirable by	Total favorable opinions	Total responding
*1. Yardstick	27	3	30	30
*2. 12-inch rulers	27	2	29	29
3. Steel or fabric tape (50 feet)	7	13	20	25
4. Set of square measures (one-inch squares set in a rectangular frame)	9	10	19	26
5. Set of cubic measures	7	11	18	25
6. Geometric solids	5	10	15	27
7. Road maps	8	11	19	25
*8. Scales and weights (avoirdupois)	12	10	22	26
*9. Dry measures (U. S. Standard)	18	8	26	28
*10. Liquid Measures (U. S. Standard)	19	7	26	29
*11. Household measures	15	9	24	27
*12. Clock	20	3	23	26
13. Stopwatch	4	10	14	26
*14. Sets of practice cards for basic facts of four fundamentals	23	5	28	30
*15. Number games	20	6	26	30
*16. Chart of fractional relationships	16	10	26	28
*17. Chart of aliquot parts	11	9	20	29
*18. Crossruled blackboard section	7	6	13	25
19. Checks	6	10	16	25
20. Deposit slips	6	9	15	24
21. Deposit books	5	11	16	25
*22. Railroad timetables	11	5	16	26
*23. Bus timetables	11	6	17	26
*24. Work table and chairs	15	5	20	27
*25. Scissors	25	1	26	27

* Considered most important.

The following items of equipment were suggested in some of the replies: toy money, a calendar, an almanac, model graphs and charts, a Fahrenheit thermometer, and the mileage meter from an automobile. Their use is obvious.

ary mathematics. These leaders are distributed over fifteen states in the East, Middle West, and Far West. They were requested to indicate their opinion of the relative importance of each item of equipment in teaching mathematics in the elementary, junior, and senior high schools. They were to indicate if they thought the item was highly important, desirable, or of little utility. Thirty-two replies were received.

The items in the list were selected on the basis of suggestions obtained from supervisors of instruction in mathematics, a survey of leading textbooks in elementary and secondary school mathematics, and an inspection of a number of books on the teaching of mathematics. The complete list of seventy-five items is included in Table I.

Items of Equipment Suggested for Use in the Teaching of Mathematics in the Elementary School

The results of the inquiry regarding the pieces of equipment useful in teaching elementary arithmetic are both interesting and significant. Twenty-five, or one-third, of the suggested items were considered favorably by the majority of the thirty-two authorities. See Table II. Sixteen of the items were thought by most of those replying to be highly important.

The twenty-five items are quite in agreement with the demands of more progressive practice. They also represent a rather wide range of equipment to be used in objectifying concepts in mathematics to be taught elementary school children. While all the items should undoubtedly be available in every school, the sixteen rated by the majority as highly important constitute a definite requirement for every school which considers itself to be modern.

It is particularly worthy of note that most of the twenty-five items can be procured at little or even no cost. Some of them, such as the set of square measures and the practice cards, can be made. Others, such as yardsticks, liquid measures, and clocks can usually be obtained from interested patrons upon request.

Items of Equipment Suggested for Use in the Teaching of Mathematics in the Junior High School

The list of items considered by the majority of the thirty-two authorities as useful in teaching mathematics in the junior high school was the most extensive of the three. Seventy-one of the seventy-five pieces were mentioned favorably by the majority

TABLE III. ITEMS OF EQUIPMENT CONSIDERED BY THE MAJORITY OF THIRTY-TWO AUTHORITIES IN THE TEACHING OF MATHEMATICS AS HIGHLY IMPORTANT OR DESIRABLE FOR USE IN JUNIOR HIGH SCHOOL (Grades 7 to 9)

Item	Considered highly important by	Considered desirable by	Total favorable opinions	Total responding
*1. Yardstick	21	5	26	27
*2. 12-inch ruler	20	4	24	25
*3. Steel or fabric tape (50 feet)	13	11	24	26
*4. Meter stick	16	10	26	27
*5. Set of square measures (one-inch squares set in a rectangular frame)	12	8	20	25
*6. Set of cubic measures (U. S. Standard)	13	9	22	25
*7. Set of cubic measures (metric)	6	11	17	24
*8. Geometric solids	16	9	25	26
*9. Blackboard compasses	17	8	25	27
*10. Desk compasses	22	3	25	27
*11. Individual protractors	22	5	27	27
*12. Blackboard protractors	18	9	27	27
13. Map of Federal Survey	3	18	21	27
*14. Road maps	12	10	22	25
15. Surveyor's transit and rod	6	13	19	23
16. Plane board and compass	5	14	19	25
17. Carpenter's square	5	17	22	27
18. Carpenter's level	4	15	19	26
19. Architect's scale	3	14	17	22
20. Set of blueprints	8	18	26	28
*21. Drawing board, T-square, and triangle	15	8	23	28
22. Drawing instruments	8	13	21	27
23. Wire for forming models	7	11	18	25
24. Scales and weights (avoirdupois)	6	17	23	27
25. Scales and weights (metric)	3	20	23	28
26. Dry measures (U. S. Standard)	6	18	24	27
27. Dry measures (metric)	4	17	21	27
28. Liquid measures (U. S. Standard)	6	15	21	25
29. Liquid measures (metric)	6	15	21	25
30. Household measures	2	18	20	26
	6	13	19	24

TABLE III (*Continued*)

Item	Considered highly important by	Considered desirable by	Total favorable opinions	Total responding
31. Water meter dial	8	14	22	27
32. Gas meter dial	9	14	23	27
33. Electric meter dial	9	12	21	26
34. Clock	8	10	18	25
35. Stopwatch	9	7	16	26
36. Chart of fractional relationships	7	15	22	26
*37. Chart of aliquot parts	11	10	21	27
38. Slide rules (practice type)	3	12	15	24
39. Demonstration slide rule	4	11	15	24
*40. Crossruled blackboard section	21	5	26	28
41. Trigonometric tables	5	15	20	26
42. Pantograph	3	13	16	24
*43. Insurance policy forms, all kinds	13	12	25	28
44. Insurance rate books	9	13	22	28
45. Interest tables	12	13	25	28
46. Tax assessment forms	8	10	18	27
47. Deeds and abstracts	3	14	17	27
48. Rent contract forms	5	16	21	28
*49. Bank note forms	12	10	22	27
*50. Checks	16	8	24	27
*51. Deposit slips	16	8	24	27
*52. Deposit books	13	11	24	27
53. Bank statements of account	11	11	22	27
54. Cashier's checks	9	11	20	28
55. Bank draft	9	11	20	28
56. Letter of credit	6	9	15	27
57. Sight draft	4	10	14	27
58. Time deposit slips	6	9	15	25
59. Stock certificates	8	13	21	27
60. Bonds	8	13	21	27
*61. Invoices	10	9	19	26
*62. Post Office money orders	14	9	23	26
63. Express money orders	10	13	23	26
*64. Telegraph money orders	10	7	17	25
65. Parcel post rate tables	10	12	22	25
66. Freight rate tables	4	12	16	26
67. Express rate tables	6	13	19	26
68. Railroad timetables	11	12	23	25
*69. Bus timetables	12	10	22	25
*70. Work table and chairs	18	4	22	27
*71. Scissors	14	9	23	27

* Considered most important.

of those replying. They are listed in Table III. Only twenty-six of the seventy-one items were counted definitely as highly important. It will be noted that these highly important items are useful in the study of measurement and geometrical figures, and in the study of business and commercial activities.

The number of items is large, but not unreasonably extensive in light of the fact that most of the mathematics in the junior high school level is largely the application of arithmetic processes. A question that may be very pertinently raised here is whether it would not be an improvement to spread this body of mathematical topics over a longer period into the more advanced grades of the high school. This would offer at least two advantages. It would reduce the high concentration of facts and applications, and provide an opportunity for the student to study the topics when he is more mature and likely more interested in them.

Here, as in the elementary grades, most of the equipment could be made available merely for the asking or by making it. Many of the pieces would not need to be constantly available.

Five additional items were suggested in the replies. They included a sundial, visual aid equipment, a sextant, and an engineer's scale. The engineer's scale was suggested as being of value in making graphs and charts, since it divides the inch into tenths.

Items of Equipment Suggested for Use in the Teaching of Mathematics in the Senior High School

The sixty-seven pieces of equipment listed in Table IV were considered by most of the authorities to be useful in teaching senior high school mathematics. Only seventeen of these, however, were rated by the majority as highly important. They are used in the study of geometry and trigonometry, and as general equipment in teaching mathematics.

The importance of extending the program of developing objective concepts of the socially useful units of measure and the instruments of business through the senior high school level appears to be fully appreciated by the authorities in the teaching of secondary school mathematics. Evidence of this is the large number of items of equipment of that nature which they suggest as desirable for use at that level. Those in charge of the programs of instruction in senior high school mathematics should certainly give due consideration to these suggestions.

TABLE IV. ITEMS OF EQUIPMENT CONSIDERED BY THE MAJORITY OF THIRTY-TWO AUTHORITIES IN THE TEACHING OF MATHEMATICS AS HIGHLY IMPORTANT OR DESIRABLE FOR USE IN SENIOR HIGH SCHOOL

Item	Considered highly important by	Considered desirable by	Total favorable opinions	Total responding
*1. Yardsticks	16	8	24	26
*2. 12-inch rulers	16	7	23	24
*3. Steel or fabric tape (50 feet)	12	11	23	27
*4. Meter sticks	17	8	25	26
5. Set of cubic measures (U. S. Standard)	7	7	14	21
6. Set of cubic measures (metric)	8	9	17	21
*7. Geometric solids	13	8	21	22
*8. Blackboard compasses	17	7	24	26
*9. Desk compasses	20	3	23	25
*10. Individual protractor	19	4	23	25
*11. Blackboard protractor	16	11	27	27
12. Map of Federal Survey	4	16	20	24
13. Road maps	4	10	14	20
14. Set of intersecting planes	13	13	26	27
*15. Surveyor's transit and rod	13	12	25	26
16. Plane board and compass	8	16	24	27
17. Carpenter's square	2	16	18	25
18. Carpenter's level	2	16	18	25
19. Architect's scale	6	11	17	26
20. Set of blueprints	6	15	21	23
21. Drawing board, T-square, and triangle	11	14	25	27
22. Drawing instruments	8	13	21	25
23. Wire for forming models	11	13	24	26
24. Scales and weights (metric)	5	9	14	21
25. Dry measures (metric)	5	9	14	24
26. Liquid measures (U. S. Standard)	6	7	13	24
27. Liquid measures (metric)	5	10	15	23
28. Household measures	3	11	14	23
29. Water meter dial	1	13	14	24
30. Gas meter dial	1	13	14	24
31. Electric meter dial	1	12	13	24
32. Stopwatch	4	11	15	25
33. Chart of aliquot parts	2	10	12	22

TABLE IV (*Continued*)

Item	Considered highly important by	Considered desirable by	Total favorable opinions	Total responding
*34. Slide Rules (practice type)	17	8	25	27
*35. Demonstration slide rule	17	8	25	26
*36. Crossruled blackboard section	22	3	25	26
*37. Trigonometric tables	20	6	26	27
38. Pantograph	6	16	22	23
*39. Insurance policy forms of all kinds	10	7	17	22
40. Insurance rate books	7	13	20	23
41. Interest tables	7	13	20	23
42. Tax assessment forms	7	9	16	23
43. Deeds and abstracts	3	13	16	24
44. Rent contract forms	4	12	16	25
45. Checks	8	8	16	23
46. Bank note forms	7	8	15	23
47. Deposit slips	8	8	16	23
48. Deposit books	7	9	16	23
49. Bank statements of account	6	10	16	23
50. Cashier's checks	3	13	16	23
51. Bank draft	3	15	18	25
52. Letter of credit	3	14	17	25
53. Sight draft	3	15	18	25
54. Time deposit slips	3	14	17	25
55. Stock certificates	7	11	18	25
56. Bonds	7	11	18	25
57. Invoices	7	9	16	24
58. Post Office money orders	6	11	17	24
59. Express money orders	6	12	18	24
60. Telegraph money orders	5	11	16	24
61. Parcel post rate tables	4	13	17	24
62. Freight rate tables	3	11	14	24
63. Express rate tables	3	13	16	24
64. Railroad timetables	3	15	18	24
65. Bus timetables	3	15	18	24
*66. Work table and chairs	12	9	21	15
*67. Scissors	9	7	16	23

* Considered most important.

Four additional pieces of equipment were suggested by those replying. They include a globe, a sundial, visual aid equipment, and an engineer's scale.

SUMMARY

The proper development of clear objective functional concepts of the common units of measure and the instruments of business activities is altogether dependent upon the opportunity afforded the learner to obtain experience with the actual objects. It is in fact axiomatic that experience determines what anyone knows about such matters. The effective use of concrete objects in teaching these concepts implies the application of the workshop or laboratory method of instruction.

This survey of authoritative opinion regarding items of equipment considered useful in teaching elementary and secondary school mathematics clearly indicates that the authorities in the teaching of mathematics highly recommend the use of a large number. The adequate incorporation of their suggestions into the program of instruction will require that teachers of elementary and secondary mathematics become more sensitive to the value of such equipment and more proficient in using them in their teaching. This in turn calls attention to the need for a program of study to determine with greater definiteness what are the most effective techniques for using equipment at the respective grade levels. It is hoped that this study will help point the way to the more functional treatment of this important aspect of elementary and secondary mathematics.

WORK WITH B VITAMINS AND NUTRITION WINS 32ND WILLARD GIBBS MEDAL

The 32nd Willard Gibbs Medal, highest award of international scope which the American Chemical Society's Chicago Section can bestow, has been given to Dr. Conrad Arnold Elvehjem, professor of biochemistry at the University of Wisconsin.

A long record of original research in chemistry brought Dr. Elvehjem the honor. In 1928 he received wide recognition with his associates for work involving trace elements in nutrition. They discovered that copper is essential to the formation of hemoglobin, the oxygen-carrying red stuff of the blood.

Later their studies revealed the place of a number of metals in nutrition, such as iron, manganese and aluminum. While at Cambridge Dr. Elvehjem conducted studies on tissue respiration which have since been applied to the study of vitamin functions. Use of nicotinic acid in prevention and cure of pellagra and other deficiency diseases developed from Dr. Elvehjem's greatest discovery: the role of nicotinic acid in animal nutrition. He is now conducting studies on the newer members of the growing family of B vitamins. For these and other researches Dr. Elvehjem will, formally be presented with the medal at a meeting of the Chicago Section of the American Chemical Society on May 20.

A BIOLOGY CLASSROOM "ZOO"

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[EDITOR'S NOTE. Mr. Wilson contributed the following article on request of the General Biology editor. It is one of a series of articles on bringing life into our biology teaching. Mr. Wilson desires communication with teachers who could provide him with lizards, tarantulas, trap door spiders, scorpions, Jerusalem crickets, pack rats, prairie dogs, or other small animals which may be tamed.]

The fundamental aim of biology teaching is to acquaint students with plant and animal forms, their functions, behavior to their environment and laws in general which govern life. No doubt it were best if classes could be conducted in the outdoors where observations could be made on plants and animals in their natural surroundings, but large classes present many obstacles to outdoor study. In populous urban centers long distances to places where Nature still retains some semblance of its undisturbed balance nearly eliminates the possibility of class work in the outdoors. It thus becomes necessary to bring "capsules" of Nature to the biology classes by way of a classroom "zoo" and school wild flower gardens.

Our biology department (Collinwood High School, Cleveland, Ohio) has the following animals in its "zoo":

One fox squirrel
Two desert tortoises (*Testudo agassizii*)
Rats in variety
Fancy deer mice; wild deer mice
Two gopher tortoises (*Testudo polephemus*)
Three box tortoises
Dace (from the creek)
Leopard frogs
One swift (an Arizona lizard)
Two alligators
One pigeon
One Boyle's King snake (*Lampropeltus getulus boylii*)
One bull snake (*Pituophis sayi sayi*)
One boa constrictor (Central American)
Several ribbon snakes
Several De Kay's snakes.

These animals are all well and apparently contented. Our biology rooms have no animal odor because the cages are kept in a sanitary condition.

It is the specific aim of this article to describe how we feed these animals, hoping that this may prove of some value to other teachers.

Let us consider the snakes first. The Boyle's King snake is a beautiful mahogany and yellow. She has laid eggs three times since I caught her in the Hollywood hills ten years ago. She is as safe to handle as an old piece of rope. Her food consists of young rats and either young or adult mice. In fact, the rats must be quite young, never larger than an adult mouse. They need not be alive, but they must be freshly killed and still warm. I usually give her the first one alive so that it will not be wasted if she refuses it. Her capacity is about five mice at a feeding. Although she is offered food once a week she never feeds so frequently. In the summer she accepts food about every two weeks. This year she has taken only one mouse between September, and December 15 and probably will take no more until early spring. After a person has had some experience with snakes he can tell by their movements when they are ready to feed.

The Texas bull snake also eats mice and rats. He has taken as many as five half-grown rats at a meal and now eats from ten to twelve month-old rats. We kill the animals before offering them to him for food placing the tail of the dead rat into the split end of a stick and making it wiggle in front of him while the rat is still warm. A rat may be killed instantly by grasping the tail and striking the head on the floor. This is much easier than using an anaesthetic, and leaves no odor which might be disagreeable to the snake. This snake finds it almost impossible to refuse living new-born rats, sometimes taking two entire litters at one feeding. Never make the mistake of trying to feed from your fingers anything but a very small snake. Once the snake has the scent of its prey it will strike at any small object which moves at close range. I had my fingers bitten several times before learning this. Do not put living rats over a month old into the cage with a snake. It may be the snake which is injured. I am speaking of non-poisonous snakes, having had no experience with any other kind. In my opinion it is too dangerous to keep venomous snakes in a school zoo. We have kept ribbon snakes (garter snakes) and De Kay's snakes for three years on a simple diet of earthworms.

Our Central American boa constrictor eats only birds. It was purchased from a man who sold it for a small sum because the snake would not feed. We soon found that it would not feed because he kept it in the basement where it was too cold (the boa is at home in a semi-tropical climate) and because it was being offered only rats as food. Although it is claimed that boas eat

small rodents our specimen certainly did not include rats in its menu. Snakes are peculiar, and some individuals seem to be very restricted in their food habits. If they are not given the food they desire they prefer to starve. Our boa ate readily after he had been warmed up for several days and took twelve sparrows for the first meal. He feeds only at night and living birds must be left in the cage over night.

A snake will usually accept food immediately after shedding of the skin. My charges are never fed forcibly. A pan of water, large enough so the snake may soak itself just before shedding of the skin, is placed in each cage. The soaking makes the old skin come off more easily. Except for the pan of water, snake cages should be absolutely dry, even for water snakes. Never expose a snake to the sun for long periods of time. Snakes and lizards can thus be killed very quickly. None of our snakes have been in the sun since we have had them in our care. The King snake has been in our zoo for ten years, the bull snake for four years, and the boa for two years. They have not been subjected to artificial radiation of any kind except to the electric light which illuminates the room. In each cage is a cardboard carton with a hole. Into this carton the snake can retire when it so desires. There is no sand, dirt, or sawdust in these cages, but several thicknesses of newspaper are spread on the bottom. This permits of easy cleaning and the snakes take no injurious substances with their food. Do not feed snakes too much at one time in very hot weather because they digest food slowly and a too abundant supply may decay before it has been digested. The snake will then regurgitate the meal and may stop feeding for a long time. Give a snake a moderate meal and offer food again immediately after the remains of the former meal have been excreted.

All our cages for snakes have glass fronts and burlap tops for ventilation. Wire screens are objectionable because many snakes scrape their noses on screens. Such injuries may become infected, to say nothing of the unesthetic appearance of injured animals. Snakes seem to be inclined to force themselves out of an enclosure with a free circulation of air. Apparently they are attracted by the air current. The soft burlap inflicts no injury and admits sufficient air and only a limited amount of light.

The desert tortoises were brought from California in 1937. Some authorities told me not to try to keep them in Ohio because the climate would be too damp for them. Our experiences

disprove the argument. We have had the tortoises for five years, and they are in perfect health. We keep them in an absolutely dry pen, four by three by one foot, with a galvanized iron pan four inches deep as a bottom. One side of the pan is supported on blocks two inches thick to tilt the bottom so that any excreted liquid may drain to one side. This keeps the animals out of the excreted moisture (about a pint a day). This liquid is removed each morning. In the winter we feed them exclusively on lettuce trimmings from the school cafeteria. The food is placed into a slatted feeding rack from which it may be removed according to the desire of the animals. No drinking water has been provided since we have had the animals in our zoo. In summer they graze in my back yard, being confined in a large bottomless box which can be moved daily to a fresh spot. Half of this box has a burlap cover so that they enjoy either the sun or shade as they desire. I have a small building behind my garage in which they are turned loose at night. I never leave them outside when I go away for fear they may get wet in a rain storm. Every time rain threatens they are immediately put under shelter. This may perhaps not be necessary. However, I still have them, so the method has been successful. When grazing, they eat the clover and dandelion blossoms first and plantain leaves next. One likes pears, the other one does not. These tortoises are absolutely trustworthy. They will not bite no matter what the provocation. Their weight is about ten pounds each.

The gopher tortoises are about six inches long. They live on a diet of lettuce and fruit. Last summer they were in the yard confined in a small box with two-inch chicken wire on the bottom, and the top half covered for shade. The wire bottom is necessary because they burrow. They were left out the entire summer, rain or shine, night and day. They graze on the lawn, preferring clover and plantain. They also seem to be in perfect health. Once a week they receive a drink of water by being placed bodily in about an inch of water in a large pan. They drink deeply, excreting the contents of their reservoir at the same time.

Box tortoises are more fussy about their food, seeming to have individual preferences. Some eat fruit only, others prefer hamburger to all else. Most box tortoises will eat bread. Ours are very fond of meal worms. They are kept dry, although this is not necessary. It is easier to care for any animal in a dry cage and there is less odor than if it were moist. A dish of drinking water is present at all times.

The lizard was sent to us from Arizona. It is a swift. We have had it for two years, and are rather proud of that fact. Perhaps it is an especially hardy individual. In the past I have not had much success with lizards, having made many mistakes in their care, but I have profited by these mistakes. Our specimen lives in an aquarium near the radiators. The aquarium has about two inches of silica sand on the bottom and a loosely fitting glass cover. It is perfectly dry except for a saucer of water in one corner. Lizards are supposed to drink drops of water found on foliage or other objects. This one does not. I have never seen it drink at all. Perhaps the dish of water is not necessary; perhaps it keeps the air just properly humid. In one end of the aquarium we keep a large handful of meal worms, in some middlings in a hole in the sand. The lizard can get them whenever he feels the need of food. In the fall and winter the lizard spends most of the time buried in the sand.

Last summer we kept him in the back yard in a small box with a half-inch mesh wire bottom and four inches of garden soil over the wire. It always burrowed in the soil in the late afternoon and came out the middle of the next morning. The box had a cover made of half-inch wire mesh which was in turn covered with a piece of glass extending well beyond the edges of the box to keep out the rain. A half-inch thick stick was placed under one corner of the glass to permit proper ventilation. The box was in the shade of a plum tree and received about two hours of sun in the afternoon. The lizard always basked in the sun, but could go into the shade offered by one side of the box. Small bones or pieces of fruit were placed in the box from time to time. This attracted a few sow bugs, ants, flies and other insects upon which the lizard fed. Apparently lizards tire of a diet of the same kind of insects (meal worms, for example) and finally refuse to eat. Ours is especially fond of green caterpillars.

Alligators require heated water if they are to feed. Ours have a submerged heater in their tank, and the water temperature is maintained at 85 to 95 degrees Fahrenheit. The secret of successful raising of alligators is to keep the water very warm day and night. No matter how long they have been kept warm alligators will stop feeding at once if chilled. They may be given raw meat of any kind, and will feed freely if warm.

The leopard frogs sit on a floating board in a large aquarium. Their feed consists of earth worms and meal worms. They become very tame and feed freely even before an audience. The

aquarium is stocked with such water weeds as cabomba and anacharis, and usually contains an abundant mixed culture of protozoa. No fish are kept in this aquarium so that the protozoa may flourish on the decaying weed and excretion from the frogs.

The dace are "minnies" from the creek. They live on ground meat and granulated tropical fish food. Give your fish meat. This applies to goldfish, tropical fish, or any other kind of fish. Mince the meat very fine and give them only as much as they will swallow. When fish are fed in this way the aquarium never becomes polluted and it will not be necessary to change the water. The water in our aquariums, barring accident, is never changed from September to June. However, do not expect your fish to live on the white rice cake sold under the name of fish food. Fish need to be fed but three times a week but should receive nourishing food. It is unwise to offer more food than they can swallow comfortably. The excess will only become a source of pollution in the water.

The rats receive a mixture of equal parts of scratch feed and rolled oats as a basic diet. With this they get a little milk from time to time, and a little lettuce or other greens every day, just enough to keep them healthy. Give them anything else which may come to hand in the table scraps or left-overs from the lunches. Rats are not choicy, and their diet should be as varied as possible. They get exceedingly tame if handled from the time their eyes open. We have black rats, white rats, cream-colored rats, hooded rats, and just rat-colored (agouti) rats. The cream-colored are, of course, pink-eyed dilute brown. The pink-eyed dilute black are a dirty white color. These pink eyed rats may or may not have the hooded pattern.

Deer mice are well adapted to school zoo care because they are absolutely free from "mousey odor." The odor of ordinary white or house mice can be detected the minute one steps into a room containing a cage full of them, no matter how clean the cage. We have orange deer mice, albino deer mice, and various shades of salmon and agouti. There are also pink-eyed dilutes. The diet for these mice is the same as for the rats except that they are very fond of acorns, chicken bones, and squash seeds. The wild deer mice were caught in the woods in live-traps made from old tin cans. All deer mice are very active and enjoy running a wheel.

The fox squirrel is a darling. She is perfectly tame and will play like a kitten. We permit her to run loose in the class room

several periods each day, and the youngsters love her. A pupil found her on the ground one cold morning last spring. She was so young that her eyes had not yet opened. He raised her on milk given with a medicine dropper. In the home she had the freedom of the house and was finally presented to the school because of the destruction she caused in the house by climbing up and down curtains and upholstered furniture, and by gnawing the edges of the piano. Her basic diet is the same as that for rats, varied with nuts and acorns and an occasional small piece of cooky. She also likes oranges, apples, raisins, and lettuce.

My particular personal pet is a barred owl which I have had for twelve years. The bird is not only tame but very affectionate. Her food consists of a rat given every night.

I have kept many other kinds of animals in the past. All have their own interesting personalities and individual differences which add fascination to their observation and study. In the course of time one learns many little details about their housing and care which finally lead to a fuller understanding of their needs. One also learns to appreciate the importance of small factors in the well being of animals. Much thought has been given the construction of sanitary cages and drinking water containers. Frequently these are so simple that they seem hardly worth mentioning, and yet they go far toward successful keeping of animals.

A school "zoo" need not be limited to vertebrates but may, or one is inclined to say, should include lower forms of animal life. Many insects such as meal worms, cockroaches, dermestids, crickets, grain moths, drug store beetles and other kinds make interesting cultures. Fresh water shrimps, too, are easily raised in the schoolroom. Techniques involved in proper care of lower animal life will form the topic of another paper.

For other "How" articles in recent issues of the JOURNAL see Mitchell, Cora D. School-sponsored Gardens as a Project in Creative Science. May, 1942; p. 441.

Grant, Charlotte L. Wild Flower Study and Conservation. October, 1942; p. 676.

MINNESOTA LOSES TEACHERS

More than 4,500 teachers have left Minnesota public school positions during the last 12 months. Only a few of these have been replaced, says Walter Englund, Secretary of the Minnesota Education Association.

NOTES FROM A MATHEMATICS CLASSROOM

JOSEPH A. NYBERG
Hyde Park High School, Chicago

(*Continued from the March issue*)

44. Proving Trigonometric Identities. Some teachers prefer to have these identities proved by replacing the equal sign between the two members with a vertical bar, and then having the student show that he can transform the left member into the right member. Other teachers use the vertical bar to separate the members but allow the student to work with both members until identical expressions are obtained. I wonder what their students are expected to do with a problem like:

Is $\cot A + \tan A = \cos A \csc A + \sec A \csc A$

an identity or an equation?

If the statement is an identity he may not assume the equality; if it is an equation, he may do so. But which is it?

In the text which I use all the methods of dealing with identities are mentioned. Since I always expect the student to read his textbook, he will be familiar with the methods when we begin the class discussion. I then start by working a problem, treating it as an equation and arriving at, for example, $\sin^2 A + \cos^2 A = 1$. I can then ask, "Have I done what I should have done?" Some pupil is sure to answer that I have proved the converse of what I should have proved since I have taken the conclusion and used it for the hypothesis. Obviously I can now write a correct proof by taking the last step and calling it the first step, and writing the steps in reverse order. It seems foolish to do the work first on scratch paper and then to copy it. The simplest thing to do is to use the writing I have already done, but merely to renumber the steps, writing 1 for the last step, 2 for the preceding step, until I reach step 8, 9, or 10 for my original identity. The question of multiplication by zero and of reversing steps needs to be settled regardless of which method is used.

The problem that was suggested above would, by this method, be treated like any other problem. If I find that it is an equation I need not renumber the steps. If it is an identity I renumber the steps.

45. Solving Quadratics in Three Ways. We often hear the argument that it is foolish to teach a pupil three ways to do something when one method will do the work. In particular,

since all quadratics can be solved by the formula, it and it alone needs to be taught. If we answer this argument by saying that the formula will have more meaning to the pupil if he sees how it is derived, we get the reply that the pupil uses a great many other formulas (from science, for example) whose derivation he does not understand. I believe there are good reasons for teaching several methods.

After the class has learned the third method I would like to assign the problem: Gather 10 or 15 quadratic equations and solve each of them by all three methods, keeping a record of the time it takes to solve each equation by each method. From your data write a report on what method is best.

It would of course be foolish to assign such a problem; no pupil would undertake the task. The problem requires the kind of thinking and experimenting that we would like to have pupils do, but it involves too much work. However the problem is too good to be discarded and so I use it as follows. I write ten or more quadratics on the blackboard and ask the class to discuss which method they would use if they wished to use the easiest way. After some discussion I write my own answers. Thus,

$x^2+4x-21=0$	Factoring
$x^2+4x-20=0$	Complete the square
$x^2+3x-20=0$	Formula
$2x^2+\ x-\ 3=0$	Factoring
$2x^2+\ x-\ 4=0$	Formula
$x^2+6x+\ 2=0$	Complete the square.

The question now is: From the data, can you devise a set of rules or offer suggestions about which method is best?

The answer that I try to get from the pupils is:

Not all quadratics are factorable; but if it is, and if the factors can be found without too much trouble, then that is the first choice.

If $a=1$ and if b is an even number, then completing the square is a desirable method. If b is an odd number, the formula is faster because the fractions take much time.

In all other cases, the formula is the best method.

All this opportunity of thinking, comparing, and analyzing is lost unless the pupil learns more than one method. If our only object is to solve quadratics then one method would be suffi-

cient. But if our object is to solve quadratics, and *also* to offer the pupil opportunities to think, then we should not neglect the topics which furnish the opportunities.

46. Deriving One Proportion from Another. In the preceding paragraphs and in other places I have mentioned the value of problems which require the pupil to compare various possible methods. In a good problem the correct method of attack must not be too obvious; in fact the best kind of problem would be one in which the obvious method would fail and the correct method could not be found until after several trials. Many geometric problems, particularly those which involve helping lines, are of this kind, but such exercises are usually lengthy and hence only a few can be attacked during a forty-minute recitation.

Problems which involve deriving one proportion from a given proportion have the desirable features. For example,

$$\text{From} \quad \frac{a}{b}=\frac{c}{d} \quad \text{derive} \quad \frac{a-c}{b-d}=\frac{a}{b}.$$

The pupil has definite tools at his command: interchange the means, interchange the extremes, invert the ratios, add the denominators to the numerators, and so forth. He can try one of the tools, then another, then another, until he finds the right combination. He can do some guessing by keeping his eye on the conclusion, but he must still experiment. The steps are not so numerous that he gets discouraged. The problems are short, and a great many can be solved during ten or fifteen minutes. The class can make an entertaining game: Let each pupil invent a problem and propose it to his neighbor.

This particular problem will not be popular with those who judge problems on the basis of the probable use in real life situations. I am thinking now of the people who would have pupils study only those fractions which are most likely to arise in daily activities, who would rate theorems of geometry according to the number of times a carpenter or perhaps an examination board uses them, or who would rate factoring according to the amount of factoring in a course in calculus. Some of the "least likely ever to be used" exercises of algebra and geometry are the best for teaching *thinking*, for developing habits of analyzing and comparing, for cultivating patience, endurance, and perseverance. Too often we talk about the disciplinary value of some subject and then proceed to eliminate the parts which have the most disciplinary value. A good mathematics teacher would

make a good diplomat; he is continually compromising between the useful work and the disciplinary work, and neglecting neither.

47. Practical versus Disciplinary Values. As an example of the difference between a practical solution of a problem and its disciplinary values, consider the problem of finding the values of the trigonometric ratios from the value of one of them. If $\sin A = 2/3$ the quickest and easiest way to find the other ratios is to sketch a right triangle, label one leg 2 and the hypotenuse 3; then the other leg is $\sqrt{5}$, and the ratios can be seen by looking at the triangle. This is the sensible way to find the ratios when the only object in life is to find them.

However, if I wish to give the student some practice with the fundamental identities, I ask him to find the ratios by algebraic methods, substituting the given ratio in various identities. I leave it to the class in pedagogy to discuss whether one or both methods should be taught.

Evidently writers of trigonometry texts believe there is something in the theory that the student should not always be told the easiest way of solving some problems. Consider, for example, the matter of identities mentioned in item 44. They can all be solved easily by substituting s/h for $\sin A$, c/h for $\cos A$, s/c for $\tan A$, and so forth. But I have never seen the method mentioned in a textbook, and I am sure every writer knows of the method.

For another example, consider the problem of expressing the ratios in terms of each other. To express all the ratios in terms of $\sin A$, I sketch a triangle, label one leg $\sin A$, the hypotenuse 1, and the other leg $\sqrt{1-\sin^2 A}$. Then from the picture I can read off any ratio in terms of $\sin A$. To express all the ratios in terms of $\tan A$, I label one leg $\tan A$, the hypotenuse 1, and the other leg $\sqrt{1-\tan^2 A}$. Certainly this method is much easier than an algebraic method based on the indentities and substitutions. The method is mentioned in Moritz's Trigonometry. I may add that I have never yet told any class anything about these short ways. One can make life too easy.

CELLULOID STORM WINDOWS

Transparent celluloid plastic sheets are being successfully used instead of glass in storm windows in cold regions. It is claimed that the plastic has a lower heat conductivity than glass and transmits and traps more radiant heat from the sun. Also it does not break easily from explosion concussions.

SYMMETRY AND CONGRUENCE

AARON BUCHMAN
Hutchinson-Central High School, Buffalo, New York

For several years, the idea of converse theorems has been discussed rather early in the term in the writer's geometry classes. However, the apt illustration, if two sides of a triangle are equal, the angles opposite are equal, and conversely, if two angles of a triangle are equal, the sides opposite are equal, had to be postponed because in the traditional development there are quite a number of intervening propositions between these two theorems.

In one recent book, the writer found this converse theorem immediately following the above mentioned theorem. This is where the converse logically belongs because of the strong relation between a theorem and its converse. However, the proof of the converse theorem, as given in this book, seems to be quite difficult for students in the seventh week of the term, involving as it does, two sets of overlapping triangles.

The writer is offering the following proof to those teachers who would like to develop this converse theorem early in the term. The proof contains but one set of overlapping triangles, depends only on the second congruence theorem, and is not too hard for beginners to follow.

THEOREM: If two angles of a triangle are equal, the sides opposite are equal.

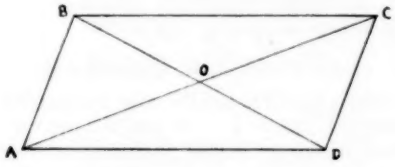
Given: $\triangle ABC$, $\angle A = \angle B$
To prove: $AC = BC$

Proof	
1. Let $\triangle A'B'C'$ be another name for $\triangle ABC$, so that A' is A, B' is B, and C' is C.	
2. $\angle A = \angle B'$	2. given
3. $\angle B = \angle A'$	3. given
4. $AB = B'A'$	4. identity
5. $\triangle ABC \cong \triangle B'A'C'$	5. a.s.a. = a.s.a.
6. $AC = B'C' = BC$	6. Corresponding parts of congruent triangles are equal.

This proof illustrates pointedly the importance of picking out the *corresponding* parts of two triangles. If this theorem is preceded by some work in overlapping triangles, the student will see that a figure may be considered to completely overlap *itself*. Cutting out the above isosceles triangle from two different colored sheets of paper pinned together will help students visualize this.

In better classes, during a discussion of symmetry the idea of a figure overlapping itself may be elaborated. It may be brought out that while *any* figure is congruent to *itself*, a *symmetrical* figure is congruent to itself in several ways, where the corresponding parts may be permuted, the number of permutations depending upon the degree of symmetry.

Thus, point symmetry is illustrated by a quadrilateral whose diagonals bisect each other. See Figure two. Here, if all the opposite vertices are interchanged, the figure transforms into itself.



POINT SYMMETRY

In this illustration, $ABCD \cong C'D'A'B'$, so that $\angle A = \angle C'$, etc., and $AB = C'D'$, etc., where, as before, A is A', etc. 0 is the center of symmetry.

A figure with one axis of symmetry is illustrated by the isosceles triangle in Figure one. Here the axis of symmetry is the bisector of angle C. Another illustration of a figure with one axis of symmetry is the isosceles trapezoid. The permutations of the corresponding parts are easily seen.

The rhombus and the rectangle illustrate figures with two axes of symmetry. These furnish interesting material for a discussion of which, and how many, permutations of the vertices leave the figure unchanged and therefore congruent to itself.

The regular polygons are figures with many axes of symmetry. Discovering the axes of symmetry in these figures, and transforming a given vertex into any other vertex by a rotation about an axis of symmetry, or by successive rotations, furnishes interesting work for the better students in the class.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

ONE HUNDRED FIFTY-SECOND MEETING

SIMMONS COLLEGE

The Fenway, Boston, Massachusetts

Saturday, December 5, 1942

MORNING PROGRAM

A Joint Session with
The New England Association of Chemistry Teachers
and
The New England Biological Association

9:45 Greetings from Dr. Bancroft Beatley, President of Simmons College.

9:50 Address: "Photography for the Science Teacher."
Mr. Richard St. Clair.

10:40 Address: "What's New in Rubber?"
Dr. E. A. Hauser, Massachusetts Institute of Technology.

11:30 Address: "War and the Teaching of Science."
Dr. John A. Timm, Simmons College.

12:20 Luncheon: Simmons College Cafeteria.

AFTERNOON PROGRAM

2:00 Address: "Physical Properties and Industrial Uses of Modern Plastics."
Professor Charles A. Stokes, Department of Chemical Engineering, Massachusetts Institute of Technology.

3:00 Address: "Problems of Home Heating."
Professor Alfred J. Ferretti, Department of Mechanical Engineering, Northeastern University.

Officers:

President: Clarence W. Lombard, High School, Hyde Park, Mass.
Secretary: Carl W. Staples, High School, Chelsea, Mass.
Treasurer: Albert R. Clish, Belmont Junior High School, Belmont, Mass.

Executive Committee:

Hollis D. Hatch, English High School, Boston, Mass.
Charles S. Lewis, Brighton High School, Brighton, Mass.
Louis R. Welch, Dorchester High School for Boys, Dorchester, Mass.

BUSINESS MEETING

Miss Elizabeth Whittemore, Concord Academy, Concord, Mass. was elected to active membership.

A report on the aeronautics questionnaire, which was circulated at the last meeting is briefly as follows:

Number of reports received	30
Schools offering a course	29
Offered in 12th grade	18

In 11th and 12th	11
In 11th only	1
In 10th and 11th	2
Recitations per week: Five	15
Four	6
Three	3
Two	3
Full year course	27
Half year course	2
Year and a half course	1
Text used: Pope-Otis	22
Teachers College	5
Army Manual	3
Nebraska	1

Number of reference books available for student use varied from 0 to 50.
Periodicals most frequently mentioned:

Current Aviation
Air News
Flying
Aero Digest
C. A. Journal

Special speakers to address class:	Yes, 16	No, 2	Blank, 10
Motion pictures occasionally:	Yes, 22	No, 1	Blank, 7
Still-film:	Yes, 19	No, 2	Blank, 9
Wind tunnel: Perhaps, 1;	Yes, 16	No, 8	Blank, 5
Model planes built by students:	Yes, 25	No, 0	Blank, 4
Airplane spotting:	Yes, 10	No, 7	Blank, 8

I only regret that we did not have a report from each member of the association. We then might have had a more comprehensive exhibit for publication. However this study may be an incentive for more teachers to undertake such a course, and it may give us all some new ideas to incorporate into our courses.

Homer W. Le Sourd

Due to the resignation of Mr. Alfred C. Webber as President in November, our Vice-President, Mr. Clarence W. Lombard, has succeeded him as president. Mr. Webber has accepted a position in research physics in New Jersey.

PHYSICAL PROPERTIES AND INDUSTRIAL USES OF MODERN PLASTICS

CHARLES A. STOKES, *Assistant Professor of Chemical Engineering, Massachusetts Institute of Technology*

It is not easy to give a rigid definition of a 'plastic,' especially in view of the common industrial terminology, which designates as 'plastics' substances that are essentially non-plastic in their final useful forms. However, the meaning of the term can be clarified and restricted by certain generalizations:

1. Plastics are amorphous[1] solids.

[1] Randomly arranged molecules as opposed to the regularly arranged molecules in a crystalline material.

2. Plastics are substances of high molecular weight.

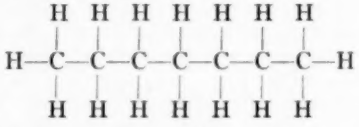
3. A plastic is not necessarily an organic substance, although most of our well-known plastics are composed of organic compounds.

4. The large molecules of a plastic may be synthesized from the smaller molecules of common substances, or may be obtained by modifying the already-existing large molecules of vegetable, animal, or mineral origin.

5. At some intermediate stage in its production a plastic must be capable of flowing under pressure so that it can be molded, extruded, cast, or otherwise shaped into the desired form.

6. A plastic must be capable of losing its plasticity (the ability to flow under pressure) to achieve the final strength and hardness that make it useful.

A well-known substance obtained from crude petroleum furnishes us with an interesting example of plastic, namely paraffin wax. Methane, CH_4, is a gas at room temperature. Gasolene is composed of a mixture of hydrocarbons of low molecular weight, typical of which is heptane, C_7H_{16}, and is a liquid at room temperature.



If the molecular size is increased to $C_{20}H_{42}$, which is normal eicosan, we obtain a solid compound, melting at 36.7°C., that meets all the requirements of a plastic except that it is crystalline rather than amorphous. However, if we prepare a mixture of compounds of the type C_nH_{2n+2}, where n is about 23 to 35, the molecules of the different compounds interfere with the formation of a regular crystalline pattern and an amorphous mixture is obtained. This is approximately the common paraffin wax; it has no definite melting point but gradually softens, finally becoming liquid, as the temperature is increased. The material has all the properties of a plastic, although its strength and hardness are low, which limits its usefulness.

Large molecules may be built up from small ones, e.g., ethylene[2] by a process known as 'polymerization.'

Many different types of compounds can polymerize, but all have a common characteristic: they must be capable of reacting with at least two other molecules. Polymerization may take place by addition of one molecule directly to a neighboring one, giving a final large molecule in which the elements are present in the same ratio as in the original small molecular units. It is also possible for molecules to join together and at the same time produce a by-product, usually water; this type of polymerization produces a polymer in which the atoms are present in a different ratio than in the elementary molecules. These types of polymerization are known as addition and condensation respectively. Two important types of polymer are

[2] Polymerizes under high pressures to produce a rubbery product reportedly having excellent electrical properties.

obtained, scientifically known as linear and three-dimensional molecules, and industrially known as thermoplastic and thermosetting.

The two kinds of molecular structure involved may be visualized with the aid of a simple analogy. If many short pieces of woolen yarn were tied together to form continuous chains composed of perhaps 100 to 1000 of the

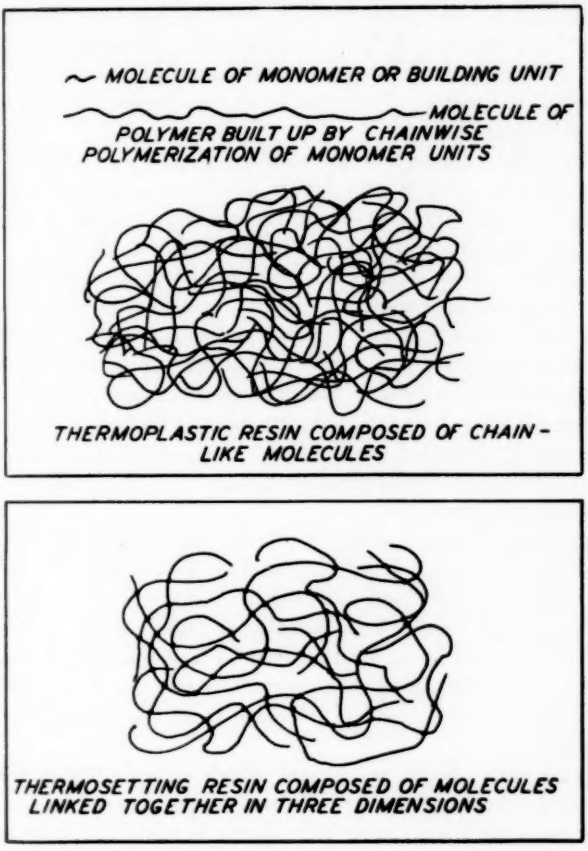

MOLECULE OF MONOMER OR BUILDING UNIT
MOLECULE OF POLYMER BUILT UP BY CHAINWISE POLYMERIZATION OF MONOMER UNITS
THERMOPLASTIC RESIN COMPOSED OF CHAIN-LIKE MOLECULES
THERMOSETTING RESIN COMPOSED OF MOLECULES LINKED TOGETHER IN THREE DIMENSIONS

FIG. 1

shorter pieces, and these chains were then snarled together in every conceivable way, one would have a model of a thermoplastic material made up of linear or chain polymers. If in some way the chains of yarn in the snarl could be tied together laterally at relatively few points distributed at random through the mass, one would obtain a model of a thermosetting plastic composed of three-dimensional molecules. The accompanying sketch shows diagrammatically the ideas just presented (Fig. 1).

It is important to remember that thermoplastic materials are characterized by their ability to soften reversibly on heating and their solu-

bility in solvents. On the other hand, thermosetting materials, when once changed into the three-dimensional structure (usually done by heating the partially polymerized resin in the presence of a catalyst), can no longer be softened or plasticized by heat and are highly resistant to solvents. Hence thermoplastics are plasticized by heating or by the action of solvents; after the softened material is shaped, it is deplasticized by cooling or evaporation of solvent. Thermosetting materials on the other hand, are usually shaped under the influence of heat while in a partially polymerized stage (before the chain-like molecules are tied together laterally) and are then irreversibly hardend by further polymerization at the elevated temperature used in the molding operation.

Our first modern plastic was the familiar celluloid, a thermoplastic which was discovered by John Wesley Hyatt, a printer, about 1870. Hyatt was competing for a $10,000 prize offered for an artificial ivory to replace that from the rapidly dwindling African elephant herds. Celluloid is made from cellulose nitrate, which in turn is a product of the nitration of naturally-occurring large cellulose molecules in the form of cotton linters, and its close chemical similarity to gun-cotton (smokeless powder) may be demonstrated easily with the aid of a match. If cellulose nitrate is kneaded with camphor and alcohol, a doughy, plastic mass is obtained. Pigments or dyes for coloring and fillers for added strength may also be mixed in on rolls. The soft mass may be extruded, pressed into blocks, and sliced to thin sheets, or molded. A seasoning period is required during which the alcohol evaporates, thus deplasticizing the mass.

A second early plastic of great importance was brought on the market in 1909 by Baekeland and is known as bakelite. This material is synthesized from phenol and formaldehyde and offers a good example of large moledules made to order from smaller ones. Bakelite is, then, a truly synthetic resin, and is often classified as such rather than as a plastic, which is a broader term. This phenol-formaldehyde compound is also one of a large group of so-called 'coal-tar resins,' which are made from the chemicals recovered from coal-tar.

Among the early plastics was casein, which was first discovered in 1890 in Germany by Adolph Spitteler, who was trying to perfect a white blackboard for use with black chalk. This plastic is made by separating curds from sour milk, washing, kneading in plasticizers and coloring materials, and shaping. The shaped article must then be set, that is, the molecules of casein are linked together at many places to form the large molecules typical of plastic materials. Several different chemicals can be used, the chief one being formaldehyde solution. Casein plastic is now largely used for buttons, having replaced the ivory nut formerly obtained from South America. It is interesting to note in passing that a new synthetic fiber is being made by extruding casein compound through tiny holes, giving a material quite similar both in chemical and physical nature to wool.

From 1870 until about 1920 the three plastics described, plus shellac and cold-molded bitumen compositions, were the only plastics to be found on

the American market. Since 1920 some 20 new plastics have been placed on the market in significant quantities. Many others have been tried out in a small way, and countless others have never gotten past the laboratory door. Needless to say, the number of possible plastics that could be made is enormous, but as in any other field a new product must be cheaply produced, available in large quantities, and have either some new properties or a slight economic advantage in order to become a success. An exception to this might be, of course, a plastic with a practically unique property, an illustration of which is the present use of methyl methacrylate (Lucite and Plexiglass).

Now that the technique of forming large molecules is being perfected, one finds that plastics can be made from many unusual materials. A case in point is the use of shrimp waste, each ton of which represents a loss of about $80 or $90 to the shrimp fisherman, to make a plastic. It would be difficult to predict the future of a plastic from such a source, even though its properties are at least competitive with other successful plastics.

It is interesting to consider the reasons why plastics are beginning to find such wide use. What are their valuable properties? First of all as their name implies, plastics are easily shaped, that is, molded, extruded, sheeted, sawed, and machined. Certain ones may also be dissolved in volatile solvents, sprayed or brushed, and upon evaporation of the solvent, a thin continuous film of the material is left behind (lacquers). Second, plastics are usually quite resistance to attack by water and atmospheric conditions that quickly tarnish and corrode metal surfaces. Many are resistant to practically all organic solvents as well, and still others resist in addition acids and alkalies of high strengths. Not to be overlooked is the factor of appearance. Plastics offer ease of colorability, smooth surfaces that may be either dull or highly polished, transparency, and many other artistic properties which make them ideal materials for all sorts of useful and ornamental articles.

Table I compares plastic materials with other common materials of construction with regard to the important mechanical and physical properties as well as cost. It is at once evident that plastics are characterized by low resistance to heat and low specific gravity. Because of their low specific gravity, they are about as strong on a pound basis as the steels. For applications where high heat resistance and mechanical strength are not important, the low specific gravity offers a decided economic advantage. It must also be pointed out that plastics are available in commercial quantities at prices ranging from about 5 cents to $2 per pound. Many of the plastics, although not of high tensile strength, are exceedingly tough and have better impact resistance than many metal alloys.

A combination of mechanical strength and toughness with high dialectric strength explains the widespread application of plastics in electrical equipment of all kinds, replacing to a large extent mica, glass, and other brittle dialectrics. A new plastic of inorganic composition, made from clay (Alsifilm), is now being perfected for this use.

TABLE I. MECHANICAL AND PHYSICAL PROPERTIES OF MATERIALS OF CONSTRUCTION

Substance	Tensile strength lb. per sq. in.	Modulus of elasticity lb. per sq. in.	Specific gravity	Melting or softening point. °F.	Approx.[3] cost per lb., cents
Nickel steel	150,000	30×10^6	8.0	2,600	30
Stainless steel	90,000	29×10^6	7.9	2,600	30
Mild steel	60,000	29×10^6	7.8	2,600	5
Aluminum alloys	20,000	10×10^6	2.7	1,200	30
Pyrex glass	10,000	10×10^6	2.2	1,500	—
Wood	8,000	—	0.55	decomposes	less than 1
Industrial plastics	4,000 to 12,000	2×10^5 to 16×10^5	1.0 to 1.6	140[4] to 350	30
Vulcanized rubber	2,500	300	about 1.0	about 300	30

In looking toward the future, one must bear in mind the relative size of the present plastics industry as compared with that of, say, the steel industry. When this is done, it becomes evident that the newspaper stories of all plastic automobile bodies and airplanes are, at least for the immediate future, out of the question. In 1940 we produced about 90,000,000 tons of steel, but less than half a million tons of plastics. One fact remains, however, and that is the synthetic rubber program will greatly expand our facilities for producing cheaply many chemicals that could be made into plastics. For example, the proposed yearly production of styrene for synthetic rubber (Buna S) alone will probably be larger than the total plastics production for 1941. Styrene can be made into a useful low-coat plastic with outstanding electrical properties and transparency. Many polystyrene (Styron) objects are on the market already. This situation exists also in other parts of the war production program; phenol, benzene, nitrocellulose, and many other potential raw materials for plastics are being produced in enormous quantities. These facts, together with the already phenomenal rate of growth of the plastic industry, make it perfectly safe to predict a doubling or tripling of the production of plastics soon after the end of the war.

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[3] These figures may be taken only as an indication of the order of magnitude of the cost.

[4] Thermosetting plastics do not soften; i.e., they decompose before softening.

PROBLEMS IN HOME HEATING

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In these troubled days, oil-rationing has forced the attention of the people to the problem of fuel conservation in the home. Regardless of the type of heating system which is installed in the particular home, whether oil, coal, or gas-fuel, steam, water, or air system, we should make every effort possible to cut down our fuel consumption. Thus the systems necessary for the transportation of this fuel, whether railroad, truck, or ship, may be utilized for the transport of other material. It is natural, therefore, that we should ask ourselves, "What can I do in my own home to lessen its fuel requirements?" Our efforts can be directed in three ways. First, modifications in the construction of the building in order to lessen heat losses from it. Secondly, improvements in the efficiency of the heating system, and finally, readjustments in our living conditions. I shall attempt to present my views of these items and at the same time to show some fallacies that have risen in the public mind relative to some of these problems.

1. BUILDING

First on the list of changes that may be made in the home to conserve heat, is the proper installation of insulation. With the usual frame type construction of our New England homes, there is a very serious heat loss through the walls and roof. The space between the studding, plaster, and outside wall, though air-filled and hence popularly expressed as an entrapped insulator, is actually a source of large convection currents, thus causing large heat losses. If this space is filled with a satisfactory insulating material, much of this loss can be eliminated. Unfortunately, the cost and labor involved to fill the space in a house already constructed is quite large, relative to the gains made, as it is necessary to blow it into each individual space between the studs. The roof, therefore, offers the best gain. If the attic floor is unfinished, the easiest, most economical and sensible method is to spread the loose insulation between the joists onto the top of the laths and plaster of the ceiling below. The weight of the insulation thus placed on the plaster is not excessive and should cause no difficulty, as the majority of the current materials used for this purpose weigh less than ten pounds per cubic foot, some being as low as 1.0 lb. per cubic foot. For an attic with a finished floor, it is necessary to raise the floor boards, to fill the space and replace the floor, or else it may (with less satisfaction) be spread loosely on the floor, or applied in blanket form to the floor. In any case, this placement of the insulation at the floor level, leaves the attic space isolated (in a heat sense) from the rest of the house. This lessens the total volume of building to be heated and likewise lessens the loss from the building, thus making possible a great saving. If it is desired to gain the use of the attic space in the insulated volume, an alternate though far more

expensive procedure is to insulate the inside of the roof. The usual practice is to fill in the space between the rafters to a depth of three inches with loose fill supported by fibre board tacked between the rafters, or by blanket type of insulation applied alone. A much more finished and thorough job is to fill the space between the rafters to their full depth, with wallboard on the under side of the rafters. In some houses, the garage space is built into the house under living rooms and hence these rooms have unusually cold floors. By filling the space between the plaster ceiling and the floor with loose insulation, not only will heat be saved, but the warm floor will give a greater sense of warmth in the room. The material used for these various insulation jobs is usually rock or silica products, generally referred to as rock wool, glass wool, fibre glass, etc., and in general, to be suitable, materials should possess high insulating value, be vermin proof, non-absorbent, non-packing, light, and non-deteriorating. The insulating materials used have a unit conductivity of 0.3 B.T.U. or less at normal temperatures.

Instead of insulating the walls of the house, some prefer to add an extra layer of shingles to the outside. This aids somewhat, especially with respect to air infiltration through the walls. That this lessening of infiltration is important, may be seen from the fact that the ordinary frame, lath and plaster dwelling allows 0.03 cu. ft. of air infiltration per square foot of surface per hour under a five mile an hour breeze, or 0.23 cu. ft. at 25 miles.

The windows of a house should next be given attention. Two methods are available, weather stripping and storm sash. Weather stripping, whether of the thorough metallic type or the less expensive felt variety, prevents the excessive leakage of air through the cracks around the frame. This cuts down the load on the heating system and also gives a greater feeling of comfort due to the elimination of drafts. However it does not help to reduce the direct loss through the window panes, nor does it prevent the condensation of moisture on cold days on the inside of the window, when higher humidities are attempted inside the house, a source of annoyance to the housewife. Storm sash, on the other hand, if properly fitted, serves as a draft eliminator, a condensation retarder, and as added insulation. There is, of course, the labor of installation and removal annually, and in many cases an unsightly appearance to the house, yet it is a primary need in the majority of our homes where we have such a large proportion of glass area in our outside walls. When it is realized that the ordinary single sash windows in a frame dwelling cause a heat loss about ten times that of the same wall area, the actual heat saving of the double sash, which has a heat conductance of 0.45 B.T.U. against 1.13 B.T.U. for single sash, is evident. The effect on the reduction of moisture condensation will be considered later. Many people offer the criticism that with the use of weather stripping and storm sash, there is insufficient air supply for ventilation and health. For the usual house this is fallacious, as enough air will enter with normal use, even under these conditions, adequately to supply the needs of the occupants, which are about ten cu. ft. per person per minute, or

about 500 cu. ft. of space. Of course, if a large number of persons congregate for lengthy periods in limited areas, some means of ventilation must be provided.

For the outside doors of the house, weather stripping, storm doors, or special enclosed vestibules should be provided, particularly in those homes in which the main entrance is so designed that it opens either directly into a living room, or into hallways with open staircases to the upper floors. The basement windows and doors should not be overlooked in this search to seal the house from excessive air penetration. The simple expedient of folding newspapers into long narrow strips and placing them between the frame and the window will do wonders in this respect.

2. The Heating System

While we do our utmost to seal the house against heat leakage and air infiltration, we must not overlook the fact that a poorly installed, ineffectively operated heating system may be the cause of much heat loss from the fuel. There are few heating installations in which some advantageous corrections cannot be made. Many of these changes, however, require the services of an experienced person, though there are many which the householder can correct by himself. Excessive temperatures in the basement are generally an indication of faulty insulation, either of the pipe lines and ducts or of the heater itself. Bare pipes, unless the basement is used as living space, are not desirable, as enough heat will be lost through the insulation and from the smoke pipe to keep the area at a satisfactory temperature. On steam and hot water pipes a thickness of about one inch of standard pipe covering and on hot air ducts of about one-half inch will pay for itself, though faulty insulation on vertical pipes may do more harm than good. The heater should be covered with asbestos or other suitable material to a depth such that the hand may be held on it without discomfort during operation of the unit. Any of these insulations can be applied with relative ease by an inexperienced person.

The most important item is not the insulation, but the proper combustion of the fuel itself. Tests on home-heating systems have shown some that are utilizing as little as 25% of the heat possible from the fuel, though the majority show nearer 50% and the better installations as high as 70%. It is evident, therefore, that increased combustion efficiency can contribute to the greatest fuel saving. The proper amount of air, correctly distributed, is a primary requisite. This requires correct draft regulation, particularly at light combustion rates. The best indication is by an analysis of the flue gases, the carbon dioxide content alone being a good measure of the combustion efficiency when properly interpreted. Ordinary anthracite fuel requires about 9.5 pounds of air per pound of coal for ideal combustion with slightly over 20% carbon dioxide formation whereas #2 fuel oil needs about 105 pounds of air per gallon of oil with over 15% carbon dioxide. Actually, from 50 to 100% in excess of these air requirements must be used

for proper operation with a corresponding reduction in the carbon dioxide content of the flue gases to about 12% for coal and 8–10% for oil. A second indication of the combustion efficiency is the temperature of the gases entering the chimney. However, it must be pointed out that temperature alone is not the entire story. People often say that their heater is very efficient because the smoke pipe is so low in temperature that you can practically hold your hand on it. This is a fallacy because the low temperature may be due to an excess of air entering over the fire box, or through a check damper, or even due to excess air through the combustion chamber. In a recent article in *Mechanical Engineering* (October, 1942), in tests on a large number of oil burning installations, the stack temperature averaged 600°F. and the carbon dioxide content 7.35%. By making suitable adjustments of the burner installation, particularly as regards reduction in excess air, these values were corrected to 550°F. and 9.35%. In another set of tests, values were changed from 8.7%, 550°F. to 9.2%, 500°F., indicating about 70% efficiency. Some of the installations indicated temperatures as high as 950°F. and as low as 330°F.; the highest carbon dioxide content indicated was 14.5%. Large excess of air should be corrected whether due to excessive draft, leakage around cleanout door, excess opening above firing level or improper adjustment of air openings. The heating surfaces should be cleaned periodically as a layer of soot on the surfaces blankets the heat transmission. Little attention is given in hot water and steam boilers to the condition of the inside surfaces of the unit, rusted surfaces not only acting as a non-conducting layer, but also interfering with proper circulation of the water. Acidity of water, entrapped air, or low solubility salts, can all add to the difficulty, as well as rust and organic matter carried into the heater from the city mains. The popular idea that water in a heater system should be changed often as it gets "stale," and therefore won't heat well, is, of course, a fallacy. It is far better to leave the water alone, particularly if it is kept clean, as it has less entrapped air than the fresh supply. In New England, our water supply in general is such that little treatment is needed, and should only be attempted by experienced persons. Keep the water level at the designed level in steam systems, use the proper size fuel and correct depth of fuel bed for the size grate used for solid fuel, and the right grade of oil for the burner tips with liquid fuel. (For anthracite fuel, egg size should be used only in furnaces 24 inches or more in diameter or less with 20-inch depth of fuel bed.) Automatic equipment, as stokers and oil burners, should be periodically adjusted to fit the fuel used and the cycle periods. Intermittent use of equipment of this type means that adjustments which might be best for continuous use will not give as good results with "off and on" use. One which might give 70% efficiency at continuous operation might drop to 50% with the same settings at 20% operation. Some of this loss is due to starting conditions and some due to excessive air circulation on the "off" period, chilling the setting. This latter can be lessened by proper equipment to check the draft

in these "off" periods as by the use of automatic stack dampers. In warm air systems, a considerable saving may be made by taking the cold air supply from the basement or other points within the house instead of from outside. Where domestic hot water heating is connected with the main heating system and provided with a basement storage tank, care should be taken to insulate the pipes and tank. The polished brass or copper tank may look more attractive, but the heat loss is large relative to one which has been insulated with asbestos or other material.

Turning now our attention to heating outlets in the rooms, the radiators of the steam and hot water systems and the registers of the warm air type. In the hot water type, frequent venting of the radiators through the air-cocks will increase the effectiveness of the radiator, thus permitting lower water temperatures for a given heating demand. Those who have used low pressure, single pipe steam systems, may have noticed, especially in the milder weather, a large temperature fluctuation even though the therm-mostat may be set with a small temperature difference. (That is, the thermo-stat will shut off the heater, but the room temperature will rise far above the desired thermostat reading, while the system will not cut in again until the room drops to the thermostat setting, and then the room will drop even below this before steam again reaches the radiators to bring the tempera-ture up again.) This is caused by air in the system and cooling of the water in the boiler below its boiling point. Before steam reaches the radiators, the burners must raise the water temperature to boiling and force the air out through the restricted openings of the air valves. Good vacuum valves on the system will lessen this difficulty, as it will delay entrance of air into the system, and thus keep the water at the boiling point at a lower pressure, even though its temperature is reduced. As long as this lowered pressure is maintained by preventing air entrance, the response of the system will be immediate. As installed in many houses, improperly sized radiation has been placed in rooms with the result that faulty heat distribution to these rooms takes place. To have comfort in one room, an adjacent room may be over- or underheated. Unfortunately, good results cannot be obtained with-out completely revamping the stem. If multiple radiators are used, some radiators can be shut off in those rooms where the heat is greatest. In vapor or hot water systems of the two-pipe type the use of regulator valves or modulation discs in these lines may be used to insure better heat dis-tribution.

The discussion of radiators always brings up controversies regarding the use of various paints on the surface of the radiator and the use of radiator enclosures. The latter have become a definite addition to the room furniture and it may be safely said that, if properly designed, they do not lessen the radiator's capacity; in fact, in some cases where radiators are close to out-side walls, if these enclosures have a metallic back to reflect the heat, they may actually improve the effectiveness of the radiator. In the case of paint-ing much of the confusion has arisen due to reference to tests on the rela-

tive radiating power of surface at solar temperatures. Under these conditions black paint gave 0.94, white paint, 0.12, and aluminum foil 0.30, that of a black body. However, at room temperatures, these values were 0.90, 0.90, and 0.50 respectively. Add to this the fact that the ordinary radiator is primarily a convector of heat and paints have little effect on this. Thus, tests on actual radiators reported by the A.S.H.V.E. Guide showed the bare radiator gave 1.77 B.T.U. per square foot, a gray paint on the same surface gave 1.78, a dull black paint, 1.76, and aluminum bronze, 1.60 and yet aluminum bronze has been the most widely used.

The use of a fireplace for supplementary heating is not only a cheerful prospect, but if used properly can add materially to the saving of other fuel. Where the fireplace is a part of a room which is not used throughout the day, the temperature as controlled by the usual heating system can be kept lower. However, care must be exercised to control the flue damper so that a minimum opening is used consistent with the fuel condition and rate of combustion, and also that it closes tightly when supposedly closed, as the heat lost by air flow through an unused fireplace may be so serious as to warrant the sealing of the fireplace opening.

3. Living Habits

Under this heading let us consider how we may correct or revise our living habits to conform to the new limitations of fuel. Many people have rooms which are unused, or the use of which could be dispensed with. The basic step here is thoroughly to isolate the space, in a heat sense, to the best of our ability from the remaining heat space. Radiators and registers in these rooms, as well as dampers in hot air pipes to them should be closed. Steam radiators offer no problem, but there may be grounds for worry in some hot water systems. Usually room temperature in these rooms will not often fall to very low temperatures and the valves leading to such radiators in modern installations are generally so constructed that the flow of water cannot be entirely shut off even though the valve is closed. This, of course, loses some heat, but this cannot be avoided unless the system is drained below the level of that radiator, the radiator removed and the line plugged. Doors to these rooms from heated space should be tight. With the present tendency to eliminate thresholds between rooms, large clearances are needed at the bottom of the door to clear rugs and mats, and strong air currents will pass under the door. This, of course, can be checked with rugs, felt, etc. A similar condition exists in used rooms, such as sleeping chambers where windows are opened at night. The loss of heat by cold air leakage from such rooms is unbelievable. The condensation of moisture on the windows of such rooms is one of the reasons why it is so difficult to carry high humidities in other parts of the house.

Any discussion of heating problems must of necessity treat with the problem of personal comfort. Many wrong ideas have arisen in this respect since so-called "comfort zones of temperature" have been discussed. Elaborate tests have shown that the human body at rest can stand a wide variety

of temperature conditions, provided that the proper humidity is maintained. These temperatures range from 67° to 75° effective temperature in summer with 71° considered the most desirable, to a range from 62° to 70° in winter with the most desirable as 66°. Now let us not be misled by these values. 71° effective summer temperature means that 71° temperature may be maintained if 100% humidity is carried, though it also means 74° dry bulb temperature and 70% humidity, 79° and 30%, or 83° at 10%. Similarly, 66° effective temperature means 66° and 100%, 68° and 70%, 72° and 30%, or 74° and 10%. It is evident, therefore, that the question of a suitable temperature for the house is closely linked with the humidity that can be carried. You have all sensed the feeling of warmth in a kitchen where much steam is forming from boiling water on the stove and then been amazed to read the thermometer in that room and find that it was a reasonable value and then on entering other rooms to feel cold, even though the thermometer reading was practically the same as in the kitchen, due to much lower humidity conditions. It sounds simple enough, therefore, to say increase the humidity to 70 or 80% and thus permit of 65° rooms with some comfort. It is easy enough in a laboratory setup or an elaborate air-conditioning system, but not so in the home. Properly equipped warm air systems can improve the humidity somewhat, as well as radiator pans, etc., but it is usually difficult to raise the humidity in the colder weather to much over 35%, which is not good for comfort, for wood furniture, or for the respiratory system. Any attempts to raise it to desired levels will bring about "sweating" at the windows and even the walls of uninsulated houses, particularly in the colder rooms, due to diffusion of the moisture from the moisture source to the cold condensing spots. Storm windows, as stated before, will aid to prevent some condensation, as will the insulated wall. In the case of walls, even though insulated, however, some infiltration takes place carrying moisture into the insulation, and the danger of this freezing in the insulated space must be considered. We must therefore, accept low humidities with the necessary higher temperatures.

What we must do, therefore, is to control our house temperatures to our needs. The effective temperatures discussed previously applied to persons at rest, and, therefore, lower temperatures are comfortable when we are working in one way or another. For example, the human body gives off about 380 B.T.U. per hour when a person is at rest and seated, 430 when standing at rest, but this increases to 600–1000 with normal activity, and to 2500 or more with strenuous efforts. The person, then, "feels" warmer when actively engaged, with the same room temperatures, than when seated. So, used room temperatures throughout the day may be adjusted to meet the activity of the occupants. During the night there is no need to maintain high temperatures for most homes. Those equipped with steam systems and automatic time switch control may set their temperatures very low as the response of the system is so rapid that the thermostat may be timed to raise the temperature to day levels only a short period before the time the occupants arise. Other systems may be a little slower to

respond, but considerable saving may be realized. If no time switch is provided, similar results may be obtained by hand control, though it may mean inconvenience to some person in the house. When houses are left vacant for a considerable portion of the day, thermostat settings of 60° or lower should be maintained, as such temperatures will not give undue discomfort to a person entering from out of doors, and in most cases the temperature can be raised to normal before the persons are ready to relax. Many people make a practice of airing out their home daily by opening windows and doors, but keeping the heating system in full operation. Of course, this should not be done now. The thermostat should be set low so that the heater will not operate during this period.

As we sit around in the evening to read, etc., we shall require our maximum temperatures for comfort, but such simple expedients as drawing the window shades, especially of the Venetian blind variety, will prevent a large radiation loss, and at the same time will meet dimout regulations. The use of heavy drapes for blackout requirements can aid in fuel saving. Rearrange the seats so that we sit nearer the radiators. It is needless to say that we must all change our ideas of what represents suitable clothing to wear indoors. Warmer clothing will have to be worn to feel comfortable at the temperatures suggested by the rationing authorities. Remember we can feel comfortable at 50° out-of-doors when suitably clothed. Try also to concentrate on the use of rooms at any given time and localize the higher heat levels in these areas, even if it means closing radiators and registers and doors to other areas at that time. These suggestions, though not complete, will, I hope, aid you to maintain comfort in spite of fuel saving. If they fail to produce results I would recommend that you take a tip from the experiences of the large air-conditioned motion picture theatres. They have found that the need for refrigeration to keep low temperatures in their summer air-conditioning systems, materially increases when exciting films are shown. So, in your home on the cold days pick out an exciting book or a thrilling radio program and watch your temperature rise!

EASTERN ASSOCIATION OF PHYSICS TEACHERS

ONE HUNDRED FIFTY-THIRD MEETING

WORCESTER POLYTECHNIC INSTITUTE
Worcester, Massachusetts
Saturday, February 13, 1943

MORNING PROGRAM

9:30 Address: "Practical Application of Physics to Mechanical Problems."
Mr. James Forrest Howe, B.S., Wire Rope Engineer of the American Steel and Wire Co., Worcester, Mass.

10:15 Address: "Physical Principles Involved in Grinding Wheels."
Dr. L. H. Milligan, Assistant Director of Research of the Norton Co., Manufacturers of Abrasive Wheels et al., Worcester, Mass.
11:15 Address: "Industrial Uses of Optical Methods."
Dr. Allan E. Parker, W.P.I.
12:00 "Camouflage Without Hocus-Pocus."
Leon Hovsepian, Instructor in Drawing, Painting, Sculpture and Camouflage, Worcester Art Museum.

1:00 Dinner

AFTERNOON PROGRAM

2:00 Demonstration of Physical Apparatus, Including a 123 per cent Efficient Humidifier, Heat Conservator and Ventilator for Homes.
2:30 Address: "Optical Method of Visualizing Air Flow."
Dr. Frank Stanley Finlayson, W.P.I.

Opportunity will be given to witness a demonstration of the "Link Trainer for Aviators" and to try your own skill or clumsiness thereat.

Dr. Morton Masius, head of the Physics Department, will give a three-minute address of welcome, but will not be at liberty until after 11:00 A.M., this being the opening day of the second semester.

BUSINESS MEETING

The following were elected to active membership:

Miss Helen V. Kennedy, Oxford High School, Oxford, Mass.
Mr. George H. Blackwell, Groton School, Groton, Mass.
Mr. Louis R. Osterman, William Barton Rogers School, Hyde Park, Mass.
Mr. James L. Marston, South High School, Worcester, Mass.

BOOK NOTICE

Fundamentals of Electricity, by Fred R. Miller, Formerly Head of Science Department, English High School, Boston, Mass. Cloth. Pages vii–220. 15×20.5 cm. D. C. Heath and Co., 285 Columbus Ave., Boston, Mass., 1943. $1.00.

This book follows the War Department outline in pamphlet PIT-101. Designed as a first level course in the fundamentals of electricity, the subject matter will find application in future courses in radio communication, aviation and in allied specialties. The discussions are excellent, the illustrations appropriate and educational. Each chapter has interesting review and test questions. At the back are general review and test questions of multiple choice and true and false types, with alternate or additional demonstrations to be used with each chapter. Fifteen laboratory exercises are also included in this section.

Chapter headings are: I—Magnetism. II—Electrostatics. III—Primary Cells. IV—The Storage Battery. V—Voltage, Amperage, Resistance. VI—Electromagnetism. VII—Meters. VIII—Heating Effects of Electric Current. IX—Work, Energy, Power. X—Induced Electromotive Force. XI—Motors. XII—Mutual and Self Induction. XIII—Rectification of Current.

George W. Seaburg, Hyde Park High School

PRACTICAL APPLICATIONS OF PHYSICS TO MECHANICAL PROBLEMS

JAMES FORREST HOWE, M.E.

In coming before you today to discuss the subject of Practical Applications of Physics to Mechanical Problems I would like to open my remarks with some comments on experience, both as a pupil and as a teacher and lecturer before various classes and societies.

It sometimes happens that a teacher or professor of some subject such as physics, chemistry, language, etc., does not get across to the pupils under him as fully as he might, the value and usefulness of a thorough knowledge of the subject, as applied to the everyday life of the individual.

For instance, the pupil who is wondering whether to study a language such as Latin, Greek, French, or Spanish should be given a clear and concise picture of what the English language is, where it came from, and approximately what percentage of the words came from each source. If a pupil could be made to realize the advantages of a language such as Latin, for instance, and that possibly 40 to 50 per cent of our English language has been taken almost bodily from the Latin, he could then see that he would recognize the meaning of many words without resource to the dictionary.

Your speaker fully believes that it is very essential at the outset, as well as throughout a course of teaching of a subject, to create in the minds of the pupils a strong desire to learn and master a subject. Whenever there seems to be a slackening of interest, some means should be employed to restore the interest, either by review or illustration.

Some 40 to 45 years ago it appeared that chemistry had become stagnated, and the chemical courses of technical schools were not too popular. Contrasted with this today there is a vast change and a very broad outlook with new synthetic products, etc., developed by chemistry, and the promise of much more progress along these lines.

Physics deals with many natural phenomena, such as kinematics, sound, light, heat, electricity, characteristics of materials, expansion, contraction, atmospheric pressure, gravity, etc. It looks at first as if it would be a simple matter to measure length accurately, but it is more or less complicated for several reasons. The length of a steel bar for instance will depend upon its loaded condition, or the amount of tension in the bar. The no load length is shorter than the loaded length. Therefore if the loaded length is required, the no load length must be shorter. For example, take a 50-foot bar length loaded to 15,000 pounds per square inch tension with a modulus of elasticity of 30,000,000. The increase in length will equal

$$\frac{50 \text{ feet} \times 12 \text{ inches} \times 15{,}000}{30{,}000{,}000} = 0.3 \text{ inches}$$

which is an appreciable amount in a steel structure. If this is not taken into account, then the stress will differ from the value that is required.

The customary method of length measurement is by means of a graduated flat steel tape, usually calibrated to be accurate under a fixed tension at some definite temperature such as 60°F.

Length varies with temperature, increasing with each degree rise in temperature, and decreasing with each degree drop in temperature. Every metal and alloy has a temperature coefficient which must be determined experimentally by the physicist for use by the engineer or machinery builder.

Thus it will be seen that the following factors enter into linear measurement—

1. Tension in material being measured.
2. Tension in measuring rod or tape.
3. Temperature at which measurement is made.

I shall discuss these in connection with measuring rope and cable lengths.

Some 35 years ago a certain consulting engineering firm with a national and international reputation erected a power transmission line in which there were several river crossings about 3000 feet long. To secure the proper sag or deflection in the center of the span it was considered desirable to have the cable measured very accurately to length, since a slight variation in length would change the sag up and down several times the amount of such variation. The engineers requested the use of a new tape and wanted all the markings on the tape calibrated. The Bureau of Standards in Washington stated that it would take several years and a very great expense to do this, so a compromise was decided on, and every ten feet was checked, a total of ten points. Each piece of cable was check-tested for modulus of elasticity before measuring, and then measured under a fixed tension before applying the socket end-fastenings. When the cables were erected in the field it was found that they were short about ten feet each. Investigation finally developed that the surveyors had made an error in measuring the base line to determine the location of the towers, which accounted for this difficulty. Not enough attention was given to the field work to match with the factory accuracy of measurement.

There are other factors involved in such a case, particularly the extension or elastic stretch of a long cable, the modulus of elasticity of which is about 15,000,000, with a load of 30,000 lbs. per square inch.

$$\frac{3000 \text{ feet} \times 12 \text{ inches} \times 30{,}000}{15{,}000{,}000} = 72 \text{ inches.}$$

This means that between no load condition and the normal load the cable lengthened by 72 inches or 6 feet. Expansion and contraction due to temperature changes is determined by applying the temperature coefficient of linear expansion per degree Fahrenheit or Centigrade as the case may be.

Applying the coefficient of 0.0000066 per degree to a cable 3000 feet long for a temperature change of 20°F. which might easily be the difference

between the temperature at the time of measurement and that at the time of installation, we have

$$3000 \times 20 \times 0.0000066 = 0.396 \text{ ft. or } 4.8 \text{ in. or } 0.24 \text{ in. per } 1°\text{F.}$$

In the case just mentioned, the cables were lengthed out by the insertion of short ten foot sections and a jumper connection made to carry the electric current around the fastenings.

Another interesting point in connection with this cable was that it was composed of a galvanized stranded high strength core surrounded by a single layer of hard drawn copper wires, one of the first installations of its kind. It was necessary to adjust the construction, in order to have both the steel core and the surrounding copper wires carry as nearly as possible proportionate loads. Tests on the completed cable showed that at the elastic limit the component parts were less than 10% away from each other. Considering the fact that galvanized steel wire has a modulus of elasticity of 28,000,000 while hard drawn copper has a modulus of around 14,000,000, this was a noteworthy achievement. Electrolytic action between copper and the zinc coated steel core was prevented by filling all voids in the steel core with a heavy asphalt compound. This kept out moisture and prevented a battery action. These cables are still in successful operation after a period of 35 years.

In connection with the end fastenings it is worth while noting that galvanized steel cables are attached to steel sockets by means of molten zinc poured at a temperature of about 900°F. In this case it was feared that 900° would be likely to anneal the copper wires, so experiments were made by cleaning the copper and galvanized wires with a ten per cent solution of hydrochloric acid, and filling the lower half with 50–50 solder and the upper half of the socket with zinc. This gave very satisfactory results and held the copper wires and zinc-coated wires perfectly.

If any of you desire more information on the details of socketing wire ropes by means of zinc, I will be glad to furnish it. Both chemistry and physics enter into the methods used. This is the one method that gives 100% efficiency and is used on all rope testing and by all rope makers for attaching sockets.

Prestressing Wire Ropes

In the past 12 years there has been developed a method of conditioning ropes and cables for bridges, radio tower guys, etc., which has come to be known as prestressing.

To understand this better, let us consider the nature of ropes and cables. Wire ropes have either hemp cores or wire centers. A hemp center wire rope is more elastic due to the nature of the hemp core, and hence is used for general hoisting purposes. It will stretch in service and is highly desirable for many classes of work. A wire center rope possesses less elasticity and less stretch but is stronger than a hemp center rope.

For stationary work, it is desirable to have ropes possessing a high

modulus of elasticity, but for bending around sheaves and drums a lower modulus of elasticity is wanted. As a hemp center wire rope is used, the initial modulus increases during its life, and, when ready to be replaced, has the highest modulus, and is less able to withstand shock.

Prestressing can only be done satisfactorily on a wire center rope. This consists in subjecting ropes or strands to loads equal to approximately 50% of the ultimate strength for periods of time sufficient to set or draw each wire tightly into place so that the yield which normally takes place is eliminated, and the rope or strand possesses a fixed high modulus, a most desirable characteristic for bridges, guys, etc. Your speaker did a large amount of experimental work in connection with the development of prestressing for rope used on suspension bridges beginning with the Poughkeepsie Bridge and prior to the erection of the George Washington Bridge at New York. Although the company with which I am connected did not obtain the contract for the George Washington Bridge, the experimental work was the basis of many subsequent jobs, among which are the Kill Van Kuhl Bridge at Staten Island, New York, the Triborough, the Whitestone Bridge, Thousand Island Bridges, Waldo-Hancock at Bucksport, Maine, two bridges at Pittsburgh, Pennsylvania, and two over the Cape Cod Canal in Massachusetts, and the San Francisco-Oakland Suspension Bridge. The first prestressed ropes to have a modulus of 20,000,000 were used for suspender ropes on the Kill Van Kuhl Bridge.

As a result of the development of prestressing, it is possible to condition rope to obtain the following values of modulus of elasticity.

6× 7 wire center ropes	22,000,000 average
6×19 wire center ropes	21,000,000 average
6×37 wire center ropes	20,000,000 average
19 wire bridge strands	26,000,000 average
37 wire bridge strands	25,500,000 average
61 wire bridge strands	25,000,000 average

With these values predetermined for him, the bridge engineer can furnish the exact lengths for the strands or ropes composing the main cables, and also the suspender ropes which will fit together in the field just as readily as any piece of machinery. It is possible to measure cable lengths to an accuracy of 1 inch plus or minus in 2000 feet or within 1/24,000 of the calculated length, thus requiring only slight shimming to make final adjustments. This has been demonstrated on numerous cable measurements. Tapes calibrated to definite mean average temperatures and definite tensions are employed, and usually are 150 feet long, graduated to feet, and the last foot graduated to inches and fractions. Benchmarks are made on the prestressed cable which is kept under the working load while being measured. Correction is made for temperature, and the results are checked by two sets of measurements which must agree. Then the end-fastenings are applied, and the cable is wound on reels for shipment to the bridge site. To

assist in the erection it is customary to stripe the cables so that when erected no twisting of the cables takes place.

Since I have already pointed out that tension changes the lengths of cables it is customary to check tensions accurately by means of deflection on say 200 feet of clear span that is provided on the prestressing apparatus which must check with dynamometer tension. All of these points must be checked carefully if the measurement is to be accurate. Before this method of precise measurement was adopted it was necessary to cut cables to length in the field and apply end fastenings which was expensive and slowed down erection very much.

I have made modulus tests on cables during prestressing using a baseline of 10,000 inches. The cable is scribed with two marks exactly 10,000 inches apart under a light initial load. Pointers are attached to the rope at these marks and 4 foot steel scales are adjusted to zero position of both pointers. These scales are graduated to 1/100 inch and are on permanent supports near the rope. Observers are stationed to read each pointer when the load is applied and reaches the value for reading. A bell signal is given simultaneously and a series of readings are taken up to 50% of the ultimate. The difference between the two readings gives the elastic movement for each load increment. In this manner a reading with an accuracy of $1/100 \times 1/10{,}000$ or 1/1,000,000 is obtained. Most valuable of all is that the behavior of a long length of cable can be studied.

Another method that is adapted to the laboratory is to take a piece of prestressed cable 15 to 20 feet long in a testing machine and apply two extensometers 180 degrees apart to the cable. These extensometers are 100 inches long consisting of one tube sliding in another with an Ames dial capable of reading to 1/1000 inch. No satisfactory extensometers being on the market it was necessary to design these especially.

The method of attaching the extensometers to the rope is to mark the rope 100″ apart and to prick punch one wire at each point. Into these punch marks are inserted the corresponding punches on the extensometer which is held tightly in place by means of U-bolts with springs and nuts. After the extensometer is anchored to the rope at the prick punch points, the extensometer is capable of adjustment so as to check the 100″ which may read 100.125 inches. Readings of extensions for loads are made and corrected to correspond to actual distance taken on the rope. This method is considered accurate from the laboratory point of view, being accurate to 1/100,000 which is more accurate than the tensile testing machine which is probably correct to 1/10% or 1/1000.

Field Measurement

It is desirable in the case of guys for radio towers to have a means for checking the tension of large guy-ropes after erection. I have invented and patented a method of doing this which has been used very successfully.

Briefly it consists in casting on a guy rope near its lower end two zinc buttons 100″ apart. One zinc button has a shoulder cut on it and the other is filed flat. The rope is put under the desired tension and a mark is scribed on one button exactly 100″ from the shoulder. At the same time a rod about 100″ long is scribed to match the buttons on the rope. When erected in the field a tension is placed on the guy until it coincides with the length on the measuring bar. A steel scale can be provided so as to allow a change of tension to be made if desired. For these measuring bars it is possible to use Invar, an alloy of nickel and steel which has almost a zero coefficient of expansion from heat changes. It has a coefficient about 1/28 that of ordinary steel. Equal tension can be provided on several guys at the same time by the use of duplicate measuring bars.

In the previous world war it was necessary on certain wire ropes that were socketed with zinc to make a change, since these ropes which were zinc-coated were attached to steel sockets, and immersed in the ocean. It was found that electrolytic action caused the zinc to be eaten away more or less rapidly requiring replacement. It was desired to correct this condition by the use of some other socketing metal or alloy. Meanwhile all work was held up. Certain physical requirements had to be met such as the melting point of the socketing material, its adhesion to steel, and its total holding power. The cost and availability of the materials determined to a large degree the experiments. About a dozen available materials and alloys were cast into cylinders $\frac{5}{8}$″ in diameter and 8″ long. A beaker containing a saturated solution of common salt, a millivoltmeter, and a coil of platinum wire were used. The salt solution in the beaker provided a battery, one electrode, the platinum, being connected to the millivoltmeter. The other electrode was one of the metals or alloys to be tested and was attached to the other terminal of the voltmeter. When all was ready it was dipped into the salt solution and the momentary and steady voltage noted. After checking these materials against each other, they were further tested against each other and against zinc and iron. An alloy of 85% lead and 15% antimony was found to give a voltage of only 0.001 to 0.002 volt, which was considered satisfactory, since any electrolytic action would be very slight. This was adopted and no further difficulty was experienced.

Your speaker was confronted with the problem of measuring the acceleration and deceleration on some elevators on which some slippage of the ropes had occurred. It was necessary to establish these values quickly, and for this purpose a fish scale and a 5-pound weight were used. The scale was for ten pounds, and graduated to $\frac{1}{8}$ pound. When the weight was hung on the scale it was at the half-way mark. By holding the scale firmly against the elevator cab with the weight hanging free, the elevator was run up and down. When the elevator started up, the scale indicated a tension in excess of 5 lbs., and the amount of increase divided by 5, and multiplied by $g = 32.16$ gave the acceleration of the elevator. An increase of $1\frac{1}{4}$ lbs. means an increase of 25% or 8.04 feet per second per second. With a descending elevator the scale will indicate a reading less than 5 pounds. In

a similar manner the acceleration is found. The deceleration may be found in a similar way. Care must be taken in this method not to record a momentary flick of the pointer, but rather to use the value which remains steady for a second or two. As soon as the elevator reaches maximum speed the pointer will rest at the 5-pound mark. While this method is crude, the values obtained compare with those taken by more complicated means and have the advantage of simplicity, ease of handling, and quickness.

The cases I have cited are some of the applications of Physics which I have used in connection with problems arising from the use of steel cables. There are others which might be mentioned, and there are also problems where physicists can be of great help in accurately determining such factors as temperature coefficients of expansion for certain definite types of steel, metallic alloys, etc. Often research is content with obtaining approximate values where a more intensive effort would result in greater accuracy.

A very good rule to follow in research is to arrange apparatus so that duplicate readings can be made, which will serve the dual purpose of eliminating errors and increasing accuracy.

In conclusion I will cite such a case. A punch for an irregular piece of steel was made from a drawing, enlarged to show its contour accurately. A lead impression of this punch was made, and a photographer instructed to enlarge it to compare with the enlarged drawing. The results were disconcerting. None of the dimensions checked. The enlargement had not been accurately done. A steel scale graduated to 1/100 of an inch was attached to the lead plate, and photographed with it. Then the plate was placed in the enlarging printing frame until the steel scale graduations showed the exact enlargement desired. A print was made and the result showed the punched hole was exactly what was required. The photograph and the drawing were identical.

PHYSICAL PRINCIPLES INVOLVED IN GRINDING WHEELS

LOWELL H. MILLIGAN, C.E., PH.D.

This talk deals essentially with some of the physical characteristics of grinding wheels themselves, and their manufacture, and is not concerned with their practical use.

What are grinding wheels? How are they made? What is their structure?

ABRASIVES

Grinding wheels and other abrasive products depend for their successful operation on a class of materials that we call abrasives. What are the qualities that make a substance an abrasive? We know that silica sand, either in the form of free grains as a sand blast, or in the natural bonded form of sandstone, is one of the oldest abrasive materials; yet today in modern manufacturing operations we depend on other materials for use

as grinding wheels. The most important of these are crystalline alumina, silicon carbide, and diamond.

The first quality a good abrasive material must have is hardness. But when we say hardness, we immediately run into difficulty because there are as many different kinds of hardness as there are ways to measure it, which is simply another way of saying that hardness is a derived quantity that depends upon other fundamental physical constants of the material. Thus we have scratch hardness, and you are all familiar with Moh's scale of scratch hardness. This is one of the best ways of defining an abrasive material but is inadequate. Its determination is qualitative and subject to various experimental errors.

Then we have indentation hardness, measured in various ways. For metals you are all probably familiar with "Brinnel" hardness, "Rockwell" hardness, "Vickers" hardness, etc. These are all indentation hardness measurements, but they are not satisfactory as a means of evaluating abrasive materials. However, a new kind of indentation hardness has recently been developed at our National Bureau of Standards known as "Knoop Indentation Hardness" after its inventor. This employs a diamond shaped diamond pyramidal indentor. Because of its peculiar shape and the light loads with which it is pressed into the specimens whose hardness is being measured, this can be used for measuring the hardness of a full range of abrasive materials even up to and including the diamond itself, which still stands far above the hardness of all other known materials.

There are many other kinds of hardness that might be listed, such as sand blast hardness, abrasion hardness, etc., but we will not consider these now.

The fundamental physical constants upon which the derived property of hardness depends are such constants as strength in tension, in compression, in shear, the various elastic sonstants, and the degree of ductility or plasticity.

Toughness and what we call point endurance are other properties that an abrasive must have to a satisfactory degree in order to stand up in use. Also, an abrasive must be refractory toward heat, because in use, particularly for modern high-production metal-removing operations, the edges of abrasive grains get very hot.

Methods of Use of Abrasives

All abrasives are used in the form of grains. They usually depend on angular edges and points to penetrate the material being ground, and cut it away by a glorified scratching process. When the abrasive is used in the form of loose grains impinging upon the work, we call the process sand blasting, or, if rubbing against the work, we call the process lapping. Abrasive grains stuck to a paper or cloth constitute sandpaper and emery cloth, depending on whether the abrasive is silica or emery.

When the abrasive grains are bonded together into a solid article, we call the products grinding wheels, abrasive sticks, etc. The bonding material

may be of the nature of a vitrified glass in vitrified bonding wheels, or cements based on sodium silicate in silicate grinding wheels, or synthetic resin in resinoid wheels, or hard rubber in rubber bonded wheels, or shellac in shellac wheels.

Structure of Grinding Wheels

Vitrified grinding wheels are composed of three constituents: abrasive grains, vitrified bond, and pores. The abrasive grains form the framework upon which the structure is built. These may be coarse in size or so fine as to constitute an almost impalpable powder. Yet in all cases the structure of the vitrified bonded product made with these grains is substantially the same except for the scale of size that is set by the abrasive grain sizes. This is often hard to believe when we look at a coarse grain snagging wheel and a fine grain wheel used for finishing glass because they appear so vastly different.

For different commercial uses it is necessary to have abrasive products of different grade, or "grade of hardness" as it is sometimes said. This has nothing whatever to do with the hardness of the abrasive grains themselves, but merely refers to the strength of the bonding. In vitrified products, soft grades are produced by using only a small amount of bond; and hard grades are produced by using considerable bond. Even in hard grade products many pores are still present and constitute an important part of the structure.

How can we measure the grade of the grinding wheel to determine whether it is properly bonded? In the old days this was judged in two ways:

(a) The wheel was dug into with a screw-driver-like tool to see if the wheel seemed to have about the same strength of bonding as satisfactory comparison wheels.

(b) The wheel was rung to see if it had reasonably good sound and seemed to be free from cracks.

The newer methods of grading grinding wheels depend upon various quantitative measurements:

(a) Sand blast hardness is determining by measuring the depth of hole produced in the wheel by sand blasting at a constricted area under sand blast conditions.

(b) Physical measurements are made to indicate

1. The volume structure of the wheel as measured by its wt/vol. This is really a determination of the volume per cent of abrasive that is present, and tells whether the volume structure of the wheel corresponds to a harder or softer grade than it should.

2. Bonding strength is indicated by the determination of the modulus of elasticity of the wheel structure by means of its vibration frequency in the natural free-free transverse mode.

Modulus of Elasticity

The modulus of elasticity of a body is a measure of the stiffness of its

structure. Measurement of the modulus of elasticity of grinding wheels has been developed from the rough qualitative "ring" observations that were made in the old days. The ring of the sound emitted by a grinding wheel when it is struck is characterized by: (a) musical pitch, (b) tone quality. A ring of poor tone quality is usually one produced by heavy internal damping of the vibrations, and may indicate that the bond is improperly matured, or that the wheel is cracked, or that a bond of very low modulus of elasticity is present.

The modulus of elasticity of the wheel structure is calculated from the musical pitch of the ring. When struck on the side near the periphery, grinding wheels vibrate transversely in four sectors.

It is well known in physics that the modulus of elasticity of a vibrating body of this kind can be expressed by the formula:

$$q = \left(\frac{d^2}{kt}\right) f^2 W,$$

where q is the modulus of elasticity, d is the diameter, t is the thickness, f is the vibration frequency, W is the wt/vol, and k is the constant relating these factors with quantitative accuracy.

Thus, having worked out the correct values of k to be used for the wheels in question, it is only necessary to measure the linear dimensions, weigh the wheel, and determine its vibration frequency, in order to have the necessary values for calculating its modulus of elasticity.

Many years ago when we first began to measure the musical pitch of grinding wheels for this purpose, our first sonometer was a banjo, and the frequency was estimated in tenths of half tones. The next step was to set up a standard series of wheels to serve as a reference of musical pitch; but it was not long before we obtained a string sonometer such as is used in the experimental physics laboratory and measured the frequencies with it.

However, as a final step in the accurate measurement of frequency, we some years ago set up electrical equipment for this purpose. A beat frequency oscillator is employed as the measuring instrument, and this in turn is kept in accurate calibration against the standard 60-cycle lighting circuit. The sound from the grinding wheel is picked up by a microphone, and a cathode ray oscillograph is used as a null point indicator to tell when the frequency of the oscillator just matches that of the wheel being measured.

Reference for further information: Lowell H. Milligan, "Abrasives and Grinding" in *Bulletin of The American Ceramic Society*. Vol. 20, no. 2, Feb. 1941.

Dr. Allan E. Parker of Worcester Polytechnic Institute gave an interesting illustrated address on "Industrial Uses of Optical Methods," in which he pointed out a very large number of industrial processes, in which optical methods have replaced older, slower, methods of testing products and materials, and controlling the quality of manufactured products.

CAMOUFLAGE WITHOUT HOCUS POCUS

LEON HOVSEPIAN
Worcester Art Museum

Camouflage has been glorified in newspapers until the average reader has begun to believe that a new industry promising a great future has been born. These dramatized news notices have helped create a fantastic conception, particularly about the camoufleur, who in the minds of the public in general is nothing less than a wizard who with great zigzag patterns painted on a factory or a battleship says, "Presto!—now you see it, now you don't." Further, it is believed that this new industry is embodied in an institution distorted beyond any semblance of architectural tradition or style and appended with a sign reading, "You don't have to be crazy to work here, but it helps."

Camouflage, or protective concealment, may be defined as the science of hiding or disguising a target from the enemy, including any and every method of confusing and misleading him as to its location, strength and purpose.

Modern camouflage begins with the first World War. Then, too, newspapers made a great deal of the dead carcasses of horses in No-Man's Land that served as disguises for snipers; the shell-blasted trees that served as observation posts, etc.

Camouflage is neither new in nature nor in warfare. Historically camouflage is mentioned in the Bible. Camouflage in one of its phases was introduced to the Wester civilization in the form of the Trojan gift-horse and as you remember, this gift horse had teeth and it proved a mistake to look for its mouth. Shakespeare makes mention of camouflage in Macbeth. General Braddock discovered the folly of leading his brightly garbed soldiers against the French and Indians who were well versed in the art of bush warfare. The bright but too frequently fatal reds, blues, and greens were replaced by neutral brown, olive drab, and grays.

In nature, animals, birds, insects, reptiles, and fish are often so colored that they are very difficult to detect when motionless against their normal backgrounds. One recommendation of importance to the camoufleur was noted by an American artist, Abbot Thayer. He described the fact that many animals were colored darker on top, becoming lighter on the sides, and almost white beneath. This process of nature he called "countershading" because it was the exactly opposite shading that an object would appear to have if placed in a normal light. Therefore, when this principle is applied on rounded objects, like the muzzle of a gun, it would tend to flatten its appearance. Combined with the vivid patterning of the zebra or the rattlesnake, it would tend to appear to lose its shape. These are two important tricks in the repertoire of the camoufleur.

The flat top is another important device used by the camoufleur and it

consists of a netting garnished with osnaburg or burlap that forms a concealing over a military or industrial installation.

World War 2 has added a new dimension directed upward. The bomber is an awesome instrument of destruction and probably the most effective weapon is camouflage. However, the aerial observer can detect camouflage with the interpretation of aerial photographs. A series of successive photographs, oblique and vertical, are taken over enemy territory. The photographic interpreter studies these photographs for signs of enemy activity and if he detects anything suspicious, he requests a stereoscopic pair of photos which can be made to exaggerate terrain features so that he can almost look under a camouflaged installation. However, these are useful to the bombardier only in planning his course and familiarizing himself with the important landmarks. To make the final attack he must recognize the target with his naked eye and with the aid of an instrument. In this mission he is handicapped by five major difficulties that congruently are advantages to the defender, i.e.,

1. The high altitude.
2. Darkness of night.
3. The oblique angle in which he must recognize his target.
4. The shortness of the time in which he must align his bomb sights.
5. Clouds or haze that might obscure his vision.

All this he must do in thirty-five seconds and his minimum target recognition is about four and one-half miles.

(Mr. Hovsepian concluded his illustrated talk by quoting the opinions of a few American and foreign observers regarding the effectiveness of camouflage.)

CURFEW

Curfew at 9 or 10 P.M. is ringing again for teen-agers in some cities to combat increase in juvenile delinquency. Bay City, Mich., adopted an ordinance fixing a 10 o'clock curfew under which violators under 16 will be considered delinquents and those between 16 and 18 misdemeanants. New ordinances in Key West and Ft. Lauderdale, Fla., carry penalties for parents as well as children, the Key West law fining parents $100 for their children's violations.

STANDARDS WILL HELP SOUTH AMERICAN TRADE

Inter-American standardization of industrial products will be promoted by a new department in the American Standards Association because of increased trade and closer cooperation with our South American neighbors.

Data on development and use of standards will be exchanged with government, industrial and technical groups. War requirements have speeded plans to provide Latin American countries with Spanish and Portuguese translations of standards which may be helpful in developing their industries.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggesions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1796. *K. A. G. Miller, Upper Canada College, Toronto.*

1800. *K. A. G. Miller and David Pilkington, Upper Canada College.*

1796. *Mary Sullivan, Blue Springs, Mo.*

1801. *Proposed by Walter R. Warne, Rochester, N. Y.*

If ABC is a triangle, prove the identity:

$$\frac{\cot A+\cot B}{\tan A+\tan B}+\frac{\cot B+\cot C}{\tan B+\tan C}+\frac{\cot A+\cot C}{\tan A+\tan C}\equiv 1.$$

Solution by Harvey Rubinstein, Brooklyn, N. Y.

Call the left member, K. Hence, changing to tangents and simplifying,

$$K\equiv\frac{1}{\tan A\cdot\tan B}+\frac{1}{\tan B\cdot\tan C}+\frac{1}{\tan C\cdot\tan A}, \text{ adding}$$

$$\equiv\frac{\tan A+\tan B+\tan C}{\tan A\cdot\tan B\cdot\tan C}$$

which is a form of the well known identity of the angles of a triangle.

$$(\tan A+\tan B+\tan C=\tan A\cdot\tan B\cdot\tan C).$$

Hence the 3rd step

$$\equiv 1 \text{ and therefore the given expression equals one.}$$

Solutions were also offered by Aaron Buchman, Buffalo, N. Y.; M. Kirk,

West Chester, Pa.; Alan Wayne, New York City; S. E. Field, Ironwood, Mich., and the proposer.

1802. *Proposed by Ezekial W. Mundy, Syracuse, N. Y.*

The sum of two odd squares cannot be a square.

First Solution by Aaron Buchman, Buffalo, N. Y.

Let the first odd square be $(2n+1)^2$, and the second odd square be $(2m+1)^2$. Then

$$\begin{aligned} S&=(2n+1)^2+(2m+1)^2\\ &=4n^2+4m^2+4n+4m+2\\ &=2(2n^2+2m^2+2n+2m+1). \end{aligned} \tag{1}$$

Since for all integral values of n and m, the second factor of (1) is odd, then S contains the factor, 2, but once, and therefore cannot be a square.

Second Solution by Alan Wayne, New York City

Set $(2a)^2=(2b-1)^2+(2c-1)^2$ where a, b, c are positive integers. Then $a^2-b^2+b-c^2+c=\frac{1}{2}$ which is impossible. Hence an even perfect square cannot be the sum of the two odd squares.

A solution was also offered by M. Kirk, West Chester, Pa.

1803. *Proposed by Ira D. Conley, Hoyts Corners, N. Y.*

Find

$$\lim_{x\to 0}\frac{\sin(\tan x)-\tan(\sin x)}{x^7}.$$

Call the given fraction, K. It reduces to the form $\frac{0}{0}$. Then

$$K=\frac{\dfrac{1}{\sqrt{1+x^2}}-\dfrac{1}{\sqrt{1-x^2}}}{x^6}.$$

By differentiation of numerator and denominator three times, one obtains

$$\lim_{x\to 0} K=\lim_{x\to 0}\frac{-\dfrac{5}{(1+x^2)^{7/2}}-\dfrac{5}{(1-x^2)^{7/2}}}{16}=-\frac{5}{16}.$$

1804. *Proposed by Norman Anning, University of Michigan.*

Given: $a^2+b^2=7$ and $a^3+b^3=10$, find $(a+b)$.

Solution by S. E. Field, Ironwood, Mich.

These equations may be written in the form

$$\begin{aligned} (a+b)^2&=7+2ab\\ (a+b)^3&=10+3ab(a+b). \end{aligned}$$

If we consider the variables to be $(a+b)$ and ab, elimination of $(a+b)^3$ and then of ab gives

$$(a+b)^3-21(a+b)+20=0$$

from which

$$(a+b)=1,\ 4,\ \text{and}\ -5.$$

It may be noted that the corresponding values of ab are -3, $\frac{9}{2}$, and 9 and the complete solution of the equations gives

$$a=\frac{1\pm\sqrt{13}}{2},\quad \frac{4\pm i\sqrt{2}}{2},\quad \frac{-5\pm i\sqrt{11}}{2}$$
$$b=\frac{1\mp\sqrt{13}}{2},\quad \frac{4\mp i\sqrt{2}}{2},\quad \frac{-5\mp i\sqrt{11}}{2}.$$

Solutions were also offered by Alan Wayne, New York City, M. Kirk, West Chester, Pa., and Aaron Buchman, Buffalo, N. Y.

1805. *Proposed by Julius Brandstatter, Los Angeles, Calif.*

Find the envelope of the family of circles whose diameters are double ordinates of the ellipse;

$$x^2/a^2+y^2/b^2=1.$$

Solution by the proposer:

(1) If we use the parametric form of the ellipse we have; $x=a\cos\theta$ $y=b\sin\theta$ where θ is the variable parameter.

(2) The equation of the family of circles is $f(x, y, \theta)=(x-a\cos\theta)^2+y^2-b^2\sin^2\theta=0$ which involves the single parameters θ.

(3) Differentiating:

$$f_\theta(x, y, \theta)=2a\sin\theta(x-a\cos\theta-2b^2\sin\theta\cos\theta)=0.$$

Neglecting the solution, $\sin\theta=0$, one obtains from (3)

$$\cos\theta=\frac{ax}{a^2+b^2},$$

from which

$$\sin^2\theta=1-\frac{a^2x^2}{(a^2+b^2)^2}.$$

By substitution in (2) and simplifying:

$$\frac{x^2}{a^2+b^2}+\frac{y^2}{b^2}=1,$$

which is the required envelope.

Note: This example appears in the 1911 edition of *Granville's Calculus* as example 6 page 210.

1806. *Proposed by George W. Rolison, Oshkosh, Wis.*

Prove that $\tan 3x\cot x$ has no values between 3 and $\frac{1}{3}$.

Solution by Aaron Buchman, Buffalo, N. Y.

Let

$$\tan 3x\cot x=k. \tag{1}$$

Replace $\tan 3x$ and $\cot x$ by their expressions in terms of $\tan x$, simplify, and (1) becomes

$$\frac{3-\tan^2 x}{1-3\tan^2 x}=k. \tag{2}$$

Solve (2) for $\tan x$, and

$$\tan x = \sqrt{\frac{k-3}{3k-1}}. \tag{3}$$

When $\frac{1}{3} < k < 3$, the fraction under the radical sign in (3) is *negative*, and tan x is imaginary. Thus, for these values of k, no real value of x satisfies (3) and therefore (1).

A solution was also offered by M. Kirk, West Chester, Pa.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editors Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below:

1801, 2, 6. *Harvey Rubinstein, Brooklyn, N. Y.*

1801, 4. *William Hessler, Oak Park, Ill.; K. A. G. Miller, R. F. Inch, James M. O'Reilly, Edgar Cook, Upper Canada College, Toronto.*

1802. *K. A. G. Miller, Upper Canada College.*

PROBLEMS FOR SOLUTION

1819. *Proposed by Julius Brandstatter, Los Angeles, Calif.*

For what values of k is $\sum \frac{1}{x^k}$ convergent and divergent?

1820. *Proposed by Fred Jones, Scott's Corners, N. Y.*

Construct a chord of a circle which shall be trisected by the sides of a given central angle of the circle.

1821. *Proposed by Grace Ansley, Montreal, Canada.*

In triangle DEF, G is taken on side EF such that $EG = 2GF$, and H is on side FD such that $FH = 2xHD$. DG and EH intersect in O. Prove that $\triangle DOH / \triangle DEF = 1/21$. A solution by Euclidean Geometry is desired.

1822. *Proposed by D. F. Wallace, St. Paul, Minn.*

$ABCDE$ is a regular pentagon inscribed in a circle and P is a point on the minor arc subtended by AB. AF and DK are perpendicular to PE; BG is perpendicular to PC; and CH and EL are perpendicular to PD.

Prove that $AF + BG + DK = CH + EL$.

1823. *Proposed by Nettie Darling, Lodi Center, N. Y.*

If the diagonals of an inscribed quadrilateral are perpendicular to each other, any line through their intersection perpendicular to one side bisects the opposite side. This is a theorem from Brahmagupta, an Indian Mathematician of the seventh century A.D.

1824. *Proposed by Hugo Brandt, Chicago, Ill.*

An oil can is cylindrical in its lower portion and conical in its upper

portion. Its surface is $S = \pi R^2$. Its volume is to be a maximum. Find r, H, h and l in terms of R, where r is base radius, H cylinder altitude, h cone altitude, and l slant height of cone. Also find cos α, where α is the apex angle and find the maximum volume.

SCIENCE QUESTIONS

April, 1943

Conducted by Franklin T. Jones
10109 Wilbur Avenue, S.E., Cleveland, Ohio

Contributions are desired from teachers, pupils, classes and general readers. Send examination papers from any source whatsoever.

It is natural that questions connected with the War Effort will be especially appreciated.

Questions on any part of the field of science; questions having to do with the pedagogy of science; new applications of old ideas; present variations of perhaps ancient questions; anything that appeals to the reader, or might appeal to other readers—all are wanted.

What interests you, will most likely, interest others also.

We will endeavor to obtain answers to all reasonable questions. It is always valuable to get questions whether we can get the answers or not.

Contributors to SCIENCE QUESTIONS are accepted into the GQRA (Guild of Question Raisers and Answerers).

Classes and teachers are invited to join with others in this cooperative venture in science.

JOIN THE GQRA!

SCRAPBOOK PICTURES OF GQRA MEMBERS

It has been suggested to the Editor that a book of pictures of members of the GQRA should be prepared. It is true that many of the contributors to SCIENCE QUESTIONS are and have been leaders in Science and Mathematics affairs.

Please send in your picture—snapshot or otherwise.

Pictures have already been received from the following members of the GQRA:—

GQRA No. 1. John C. Packard, D.Sc., Brookline High School (deceased).

No. 4. William W. Johnson, Mechanical Engineer, The National Acme Co., Cleveland, Ohio: Instructor in Practical Mathematics, John Huntington Polytechnic Institute, Cleveland.

No. 56. I. N. Warner, State Teachers College, Platteville, Wis., Mathematics.

No. 430. Arthur O. Baker, Supervisor of Science in the Junior and Senior High Schools, Cleveland, Ohio.

SCIENCE AND INDUSTRY

Read the following to Keep Up in 1943.

39. "America's First Crucible Steel"—the twentieth of a series of stories relating chapters in the history of the Iron and Steel Industry in America. (Free on application to Iron and Steel Institute, 350 Fifth Avenue, New York, N. Y. Send your requests through SCIENCE QUESTIONS Dept.)
40. "Romance of the Smithsonian Institution" (FREE for the Asking). Write to Smithsonian Institution Series, Inc., 500 Fifth Ave., New York, N. Y.
41. "Magic in a Bottle"—by Milton Silverman, Ph.D. Ask the Macmillan Company, New York, for a descriptive circular. Get your Library to buy it for you. 314 pp., $2.50.
42. "How to Read Military Maps" by Roderick Peattie (*George W. Stewart, $1.50*). Useful to soldiers, marines and airmen now, and to young people who will presently be in service.

SOYBEAN RUBBER

999. *What is NOREPOL?* (*Science News Letter*, February 6, 1943, page 85.)

Answer—Norepol is a rubber-like material synthesized from soybean, corn and other vegetable oils by U. S. Dept. of Agriculture chemists at the Northern Regional Laboratory in Peoria, Ill.

Norepol is a combination-word formed from the first syllables of NOrthern REgional POLymer. It is a polymer of lineoleic acid. A polymer is a compound with big molecules, formed by welding together smaller molecules of other compounds. As a rule, polymers are "thicker," more solid, and harder or more elastic than the substances from which they are made.

Norepol is not a full substitute for rubber. Its stretchability is one-third that of rubber. Its tensile strength is one-sixth that of rubber. It resists aging and is impervious to water and alcohol, so that it can replace rubber in shoe heels, fruit jar rings, gaskets and tubing.

Natural rubber from *kok-saghyz* roots (dandelion rubber) is in process from the crop of roots seeded from 18,000 lb. of seed imported from Russia this year. *Guayule* is making a small beginning. This planting was by the Intercontinental Rubber Co. prior to Pearl Harbor.

SNOWFALL AND RAINFALL

1000. *What is the average snowfall for the United States?*

Answer—For the whole United States, the average snowfall is 28 inches. (*Science News Letter* for January 16, 1943, page 41.) 28 inches also represents the average total precipitation. Florida and California are omitted from snowfall calculations. One inch of snow melts down to one-tenth inch of water.

The thickest mantle of snow ever recorded for one spot in the United States was 884 inches (more than 73 feet) measured at Tamarack, Calif. in the winter of 1906–7.

NIGHT EYES

1001. *How visible are small lights in the night?*

Answer—Shut away all sources of light for a half-hour, or put on a blindfold and then try to go about without lights and you will find what

a wonderful light-gatherer that eye of yours is. (*Science News Letter* for June 6, 1942, page 358.)

Night vision is far more sensitive than daylight vision.

Night eyes are colorblind.

Red is seen equally well by night and day vision.

Blue light affects your night eyes 1000 times as much as it does your day eyes.

Night eyes lack sharp vision for detail.

Some of the visible things in a black-out are:—

(From *Best's Insurance News*, January, 1943)

The glow of a cigarette or cigar is visible ¾ mile away.
The flame of a match can be seen for one mile.
Light from a flashlight is visible for 1½ miles.
Light from a 100-watt lamp can be seen for 12½ miles.
Automobile headlights are visible for 20 miles.

If you must go out during a black-out, close your eyes for two or three minutes and, when you open them again, you will be amazed at the way your vision has been adjusted.

ELECTRIC FISH

1002. *What do you know about the electric eel? the torpedo fish?*

(Refer to *American Journal of Physics*, February, 1943, pp. 13–22. Article *ELECTRIC FISH* by R. T. Cox, New York University.)

HERE'S THE $64,000 QUESTION

1003. *From an advertisement of Walter Kidde & Company, Inc., 246 West Street, Bloomfield, N. J.*

"What fire-killer would you pick for fighting a blaze in a varnish kettle? an electric motor? rubbish? carbon bisulphide? rubber cement?

Answer—From a copy of the advertisement that appeared in *Best's Insurance News*, February, 1943. A letter to Kidde would undoubtedly get you a copy of the ad and some of the excellent pamphlets on fires they publish.

Look at the Underwriters' labels on the various extinguishers. An "A" extinguisher is OK for use on a Class "A" fire (wood, rubbish, paper, etc.); "B" extinguishers for Class "B" fires (flammable liquids); "C" extinguishers for Class "C" fires (electrical).

ELECTROCHEMISTRY AND THE GLOBAL WAR

980. *Suggested by a chapter in The Drama of Chemistry by Sidney J. French, Ph.D., Professor of Chemistry, Colgate University.*

(a)—Where do the following names fit into the story of electrochemistry?

Ostwald—Electrolytic dissociation of electrolyte in water solution;

Berzelius—Atoms possess either positive or negative electricity;

Alcoa—Electrolysis of fused cryolite solution with deposit of aluminum at one electrode;

Faraday—In 1833 concluded that conducting solutions were broken up by the current into charged atoms (ions), and the metal was deposited at the negative pole;

Hooker—Electrolytic cell that bears his name;
Davy—Decomposition of the fixed alkalies, potash and soda, by the current of Volta's pile;
Hall—Discovered that fused cryolite was a conductor of the electric current, thus making the production of aluminum by electrolytic action possible;
Mag-cell—Electrolysis of magnesium in a cell the atmosphere is neutral to the metal deposited;
Arrhenius—Theory of ionization, electrolytes and non-electrolytes;
Dow—Magnesium from sea-water; bromine from brines of Michigan;
Volta—Pile of alternating plates of dissimilar metals with cloth between wet with acid; the Voltaic pile, a source of electric current;

(b)—Davy was the first electro-chemist (1778–1829). He electrolyzed fused potassium oxide by current from the Voltaic pile.

(c)—The making of the light metals, aluminum and magnesium, by electrolysis are outstanding accomplishments of the war effort. Both, however, are peace-time products.

A PEACE-TIME PROBLEM

982. *Proposed by W. R. Smith, GQRA, No. 176, Sutton's Bay, Mich.*

"Here is something that occurred to me the other day and it may interest your clientele. (If they can think of anything besides the war.)

"I have an ordinary automatic water supply system with pressure tank. The automatic switch is set to start the pump motor when the pressure falls to 20 lbs. and stop it when the pressure reaches 40 lbs.

"What would be the optimum amount of air to have in the tank when the system is put into operation? That is—the amount which would cause the pump to operate least frequently and give the largest supply of water between pumpings."

(Query, is the answer somewhere in the neighborhood of 20 lbs.?)

Answer by G. E. Morr, Inquiries Division, The F. E. Myers & Bro. Co., Ashland, Ohio. Pumps, Water Systems, Sprayers, etc. (Elected to the GQRA, No. 433.)

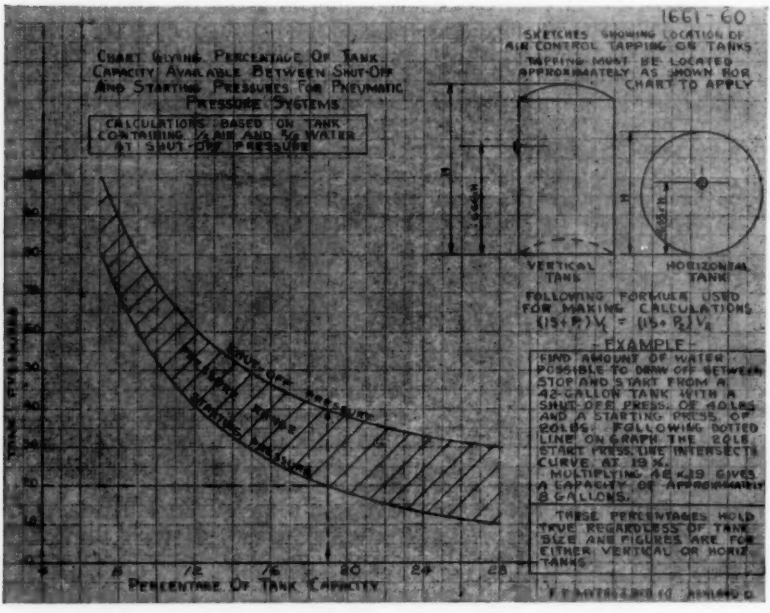
"The question asked by Mr. W. R. Smith of Sutton's Bay Michigan on his note attached with this letter is interesting and we believe that we are prepared to answer it entirely.

The accompanying chart #1661–60 was prepared recently with the thought of providing accurate information about the amounts of water that can be withdrawn from pressure tanks within normal switch settings. The form 1a on which we have based our calculations is shown on the chart.

"In a few words, the formula to determine the percentage available from a pressure tank is 15 lbs. atmospheric pressure plus the cut-out pressure divided by 15 lbs. atmospheric pressure plus the cut-in pressure. The cut-out and cut-in pressures in this case are 40 lbs. and 20 lbs. respectively. Now, multiply the result by .333 which is the percentage of tank volume in air at the cut-in pressure and subtract .333 which is the percentage of air at the cut-out pressure. The result is .19 on the normal switch setting of 20 to 40 lbs. Now multiply .19 by the total capacity of the pressure tank and the amount of water that will be released between the switch settings will be indicated.

"We have developed a chart from the results shown on the white print

but it is not yet available for publication. If you will write us in about thirty days' time and make reference to our letter of this date we may have the simplified chart available. Note that in all cases, our calculations are based on the pressure tank containing one-third air and two-thirds water at the shut-off pressure of the switch.


1661-60
CHART GIVING PERCENTAGE OF TANK CAPACITY AVAILABLE BETWEEN SHUT-OFF AND STARTING PRESSURES FOR PNEUMATIC PRESSURE SYSTEMS
CALCULATIONS BASED ON TANK CONTAINING 1/3 AIR AND 2/3 WATER AT SHUT-OFF PRESSURE
SHUT-OFF PRESSURE
STARTING PRESSURE
PERCENTAGE OF TANK CAPACITY
SKETCHES SHOWING LOCATION OF AIR CONTROL TAPPING ON TANKS
TAPPING MUST BE LOCATED APPROXIMATELY AS SHOWN FOR CHART TO APPLY
VERTICAL TANK
HORIZONTAL TANK
FOLLOWING FORMULA USED FOR MAKING CALCULATIONS
EXAMPLE
FIND AMOUNT OF WATER POSSIBLE TO DRAW OFF BETWEEN STOP AND START FROM A 42-GALLON TANK WITH A SHUT OFF PRESS. OF 40 LBS AND A STARTING PRESS. OF 20 LBS. FOLLOWING DOTTED LINE ON GRAPH THE 20 LB START PRESSURE INTERSECTS CURVE AT 19%. MULTIPLYING 42 × .19 GIVES A CAPACITY OF APPROXIMATELY 8 GALLONS.
THESE PERCENTAGES HOLD TRUE REGARDLESS OF TANK SIZE AND FIGURES ARE FOR EITHER VERTICAL OR HORIZ. TANKS

"Whenever you have any problems about water pumping equipment we will be glad to have you contact us and we will make every possible effort to assist you correctly. It is our business and our pleasure to do this which of course places you under no obligation whatsoever."

FIFTY YEARS AGO IN STEEL

"The biggest gun ever made in America—a 13-inch gun designed to hurl an 1100-pound projectile from 11 to 20 miles—was under production in 1892. Today's big guns fire a 16-inch shell, weighing over 2000 pounds, and have an effective range of 28 miles" (*American Iron & Steel Institute*).

Note that News Reports indicate that the *Jean Bart* was sunk and destroyed in the harbor of Dakar in 1942 by shots aimed by radio from a vessel 26 miles away!!!

Please submit Questions, Answers, and Solutions

JOIN THE GQRA!

I know of no adequate evidence that man to-day is a better animal physically or mentally than at the dawn of history.

—Dr. Albert Francis Blakeslee.

BOOKS RECEIVED

LEARNING TO NAVIGATE, by P. V. H. Weens, *Lt. Commander, U.S.N. Retired*, and William C. Eberle, *Lt. Commander, U.S.N.R.* Cloth. Pages viii+135. 14×23.5 cm. 1943. Pitman Publishing Corporation, 2 West 45th Street, New York, N. Y. Price $2.00.

A START IN METEOROLOGY, by Armand N. Spitz, *In Charge of Department of Meteorology, The Franklin Institute, Philadelphia, Pennsylvania and Instructor in Meteorology, Air-Mar Navigation Schools.* Cloth. 95 pages. 13×19.5 cm. 1942. The Norman W. Henley Publishing Company, 17 West 45th Street, New York, N. Y. Price $1.50.

AIR NAVIGATION FOR BEGINNERS, by Scott G. Lamb, B.S., M.S., *Lieutenant Commander, U. S. Navy, Retired, and Instructor in Navigation, Air-Mar Navigations School, Franklin Institute, Philadelphia, Pennsylvania.* Cloth. 103 pages. 13.5×19.5 cm. 1942. The Norman W. Henley Publishing Company, 17 West 45th Street, New York, N. Y. Price $1.50.

FUNDAMENTALS OF MACHINES, by John A. Clark, *Formerly Chairman of the Standing Committee on Science for the Public Schools of New York City, and Head of Department of Physical Science, Alexander Hamilton High School, Brooklyn;* Frederick Russell Gorton, *Formerly Head of the Department of Physics and Astronomy, Michigan State Normal College;* Francis W. Sears, *Associate Professor of Physics, Massachusetts Institute of Technology;* with the Editorial Assistance of Major Francis C. Crotty, *U. S. Army, Director of Training, Watertown Arsenal, Watertown, Massachusetts.* Cloth. Pages xi+300. 14×21.5 cm. 1943. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.24.

FUNDAMENTALS OF MACHINES, by Charles E. Dull, *Head of Science in West Side High School, Newark, New Jersey, and Supervisor of Science in Newark's Junior and Senior High Schools;* and Ira G. Newlin, *Head of the Science Department in the Scarsdale, New York High School.* Cloth. Pages xvi+547. 13×18.5 cm. 1943. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $1.48.

FUNDAMENTALS OF ELECTRICITY, by Charles E. Dull, *Head of Science in West Side High School, Newark, New Jersey and Supervisor of Science in Newark's Junior and Senior High Schools;* and Michael N. Idelson, *Head of Science in the Abraham Lincoln High School of New York City.* Cloth. Pages xx+456. 13×18.5 cm. 1943. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $1.48.

A MATHEMATICS REFRESHER, by A. Hooper, M. A., *Port Albert, Ontario.* Cloth. Pages x+342+xiv. 13×19.5 cm. 1942. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $1.32.

ESSENTIAL MATHEMATICS, by Frank J. McMackin, *Principal, William L. Dickinson High School, Jersey City, New Jersey;* and Roscoe P. Conkling, *Principal, Barringer Accredited Evening High School, Newark, New Jersey.* Cloth. Pages viii+372. 15×23.5 cm. 1943. Ginn and Company, Statler Building, Boston, Mass. Price $1.48.

ESSENTIALS OF ALGEBRA, COMPLETE SECOND YEAR COURSE, by Walter W. Hart, *Author of Mathematics Texts.* Cloth. Pages vii+472. 13×20 cm. 1943. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.68.

ESSENTIALS OF BUSINESS ARITHMETIC, by Edward M. Kanzer, *James Monroe High School, New York City and Teachers College, Columbia University;* and William L. Schaaf, *Assistant Professor of Education, Brooklyn College.* Revised Edition. Cloth. Pages viii+476. 13.5×20 cm. 1943. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.48.

ELEMENTS OF RADIO, by Abraham Marcus and William Marcus, Prepared under the Editorship of Ralph E. Horton. Cloth. Pages xiii+699. 15×22.5 cm. 1943. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Text Edition (Special Edition for Schools Only), One Volume, $3.20, Two Volumes $1.96.

MATHEMATICS FOR PILOTS, Published under the Supervision of the Training Division, Bureau of Aeronautics, U. S. Navy. Cloth. Pages ix+157. 11×19 cm. 1943. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price 75 cents.

PHYSICS MANUAL FOR PILOTS, Published under the Supervision of the Training Division, Bureau of Aeronautics, U. S. Navy. Cloth. Pages ix+229. 11×19 cm. 1943. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price 90 cents .

AIR NAVIGATION, PART ONE, INTRODUCTION TO EARTH, Published under the Supervision of the Training Division, Bureau of Aeronautics, U. S. Navy. Cloth. Pages xi+79. 20.5×28 cm. 1943. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $1.00.

AIR NAVIGATION, PART TWO, INTRODUCTION TO NAVIGATION, Published under the Supervision of the Training Division, Bureau of Aeronautics, U. S. Navy. Cloth. Pages xi+79. 20.5×28 cm. 1943. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $1.00.

MEASUREMENT AND EVALUATION IN THE SECONDARY SCHOOL, by Harry A. Greene, Ph.D., *Professor of Education and Director of Bureau of Educational Research and Service, University of Iowa;* Albert N. Jorgensen, Ph.D., *President, University of Connecticut;* and J. Raymond Gerberich, Ph.D., *Associate Professor of Education and Director of Bureau of Educational Research and Service, University of Connecticut.* Cloth. Pages xxvi+670. 14×21.5 cm. 1943. Longmans, Green and Company, Inc., New York, N. Y. Price $3.75.

PRE-SERVICE COURSE IN ELECTRICITY, by William C. Shea, *Instructor in Applied Science and Coordinator of Defense Activities and High School Subjects, Straubenmüller Textile High School, New York City.* Cloth. Pages vi+276. 13.5×21.5 cm. 1943. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.52.

PRE-SERVICE COURSE IN SHOP PRACTICE, by William J. Kennedy, *Instructor in Machine Shop Practice, Straubenmüller Textile High School, New York City.* Cloth. Pages v+339. 13.5×21.5 cm. 1943. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.52.

THE PHYSICAL SCIENCES, by George S. Eby, *Stockton Junior College, Stockton, California;* Charles L. Wauch, *Richmond Union High School, Richmond, California;* Herbert E. Welch, *Stockton Junior College, Stockton, California;* and Major Burdette H. Buckingham, *Signal Corps, Army of the United States.* Cloth. Pages vi+493. 17.5×25 cm. 1943. Ginn and Company, Statler Building, Boston, Mass. Price $2.28.

WARTIME BOOKS

THE SUPERHET MANUAL, Edited by F. J. Camm, *Editor of "Practical Wireless," "Practical Engineering," and "Practical Mechanics."* Cloth. 135 pages. 13.5×21.5 cm. 1942. Chemical Publishing Company, 234 King Street, Brooklyn, N. Y. Price $2.50.

This book gives the fundamental principles of radio, problems of selectivity, valve fundamentals, the superheterodyne principle, selectivity, noise suppression and tone control. Excellent for radio classes and service men.

STRATEGIC MATERIALS AND NATIONAL STRENGTH, by Harry N. Holmes, *Professor of Chemistry in Oberlin College, Oberlin, Ohio.* Cloth. 106 pages. 13.5×20.5 cm. 1942. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.75.

This is an excellent book for everyone to read at this time when all are inconvenienced by the war demands. Dr. Holmes discusses all sorts of materials and shows what scientists can do to relieve some of the shortage problems.

FUNDAMENTALS OF MACHINES, by Burton L. Cushing, *Head of the Department of Science, East Boston High School, and Lecturer on the Teaching of Physics at the Harvard Graduate School of Education.* Cloth. Pages x+436. 13.5×20 cm. 1943. Ginn and Company, Statler Building, Boston, Mass. Price $1.24.

A textbook for a one-semester course for high school boys preparing for war work. It is well illustrated and filled with good problems. Excellent for those preparing for the air forces or for the many branches of the army ground work and supply services.

FUNDAMENTALS OF ELECTRICITY, by Lester R. Williard, *Thomas Jefferson High School, Elizabeth, New Jersey.* Cloth. Pages vi+351. 13.5×20 cm. 1943. Ginn and Company, Statler Building, Boston, Mass. Price $1.24.

A companion to the above book designed to give the essentials of electricity to high school students who must get the basic facts and know how to use them. Laboratory work is carried along with the theory.

SUBMARINES, by Herbert S. Zim, Ph.D., *Head of the Science Department at one of the New York Ethical Culture Schools.* Cloth. Pages xii+306. 14×21 cm. 1942. Harcourt, Brace and Company, 383 Madison Avenue, New York, N. Y. Price $3.00.

This book tells the story of the submarine from the early types to the modern ones; how it is constructed and operates; its weapons and its enemies. The book is highly illustrated and the story well told.

PARACHUTES, by Herbert S. Zim, Ph.D., *Head of the Science Department at one of the New York Ethical Culture Schools.* Cloth. Pages xii+252. 14×21 cm. 1942. Harcourt, Brace and Company, 383 Madison Avenue, New York, N. Y. Price $2.50.

A very interesting book on an old device that has been put into practical wartime use in the present war. The author discusses in an interesting and scientific manner the use of the parachute in both war and peacetime.

APPLIED SCIENCE, by Charles Wilbur Banks, C.E., *Head of Department of Applied Science, Wentworth Institute, Boston.* Cloth. Pages viii+212. 14×21.5 cm. 1942. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.75.

A textbook which includes selected principles of physics and its applications in mechanics, strength of materials, electricity, and heat. Its discussions are brief and its problems many.

ELEMENTARY METALLURGY, by W. T. Frier, B.S., *Foundry Control Chemist, General Electric Company, Erie Works; Instructor in Metallurgy, General Electric Technical Night School, Erie Works.* Cloth. Pages ix+207. 15×20.5 cm. 1942. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $.75.

This is a book for the beginning student in metallurgy. No previous knowledge of chemistry or physics required. The illustrations are excellent. Short lists of questions follow each chapter.

FOR THE FLIGHT STUDENT

WAYS OF THE WEATHER, by W. J. Humphreys, Ph.D., Sc.D., *Meteorological Physicist (Retired Collaborator), United States Weather Bureau.* Cloth. 400 pages. 16.5×25 cm. 1942. The Jaques Cattell Press, Lancaster, Pa. Price $4.00.

This book has been written by an eminent author for all who want fundamental and correct knowledge of the weather. It is a work of art as well as one of science, containing many excellent half-tone illustrations. A good book for any library.

PRINCIPLES OF FLIGHT, by Bert A. Shields, *Lt. Comdr., U.S.N.R., Chief Instructor in Charge of Civilian Pilot Training, Polytechnic Institute of Brooklyn.* Cloth. Pages vii+363. 14×20.5 cm. 1942. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $1.88.

Here is a text for the high school class in aviation. It discusses the history of the airplane, its anatomy, the materials used, the forces exerted, its stability and control. Flight instruction is well discussed; safety devices and the various flight instruments are explained.

PRINCIPLES OF AIRCRAFT ENGINES, By Bert A. Shields, *Lt. Comdr., U.S.N.R., Chief Instructor in Charge of Civilian Pilot Training, Polytechnic Institute of Brooklyn.* Cloth. Pages ix+378. 14×20.5 cm. 1942. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $1.88.

This book, written for high school students, gives all the essential information about the aircraft engine. It is made up of nine separate chapters as follows: Aircraft Power Plants, Principal Parts of Aircraft Engines, Carburetion, Ignition Systems, Lubrication, Engine Instruments, Propellers, Engine Operation, and Engine Servicing.

PROCESS PRACTICE IN THE AIRCRAFT INDUSTRY, by Frank D. Klein, Jr., *Senior Metallurgist, Materials Control Branch, United States Army Air Forces.* Cloth. Pages xii+266. 15×23 cm. 1942. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.75.

A book for reference and instruction on the processes, methods, and materials of the aircraft industry.

BEFORE YOU FLY, ESSENTIALS OF AERONAUTICS, by Pearle Thurber Robinson, M.A., *Teacher of Preflight-Aeronautics, George Washington University, Washington, D. C.;* Frederic A. Middleton, B.A., *Teacher of Preflight Aeronautics, Washington High Schools, Washington, D. C.;* George M. Rawlins, Jr., Ph.D., *Head of the Department of Science in the*

Washington Elementary and Junior and Senior High Schools, Washington, D. C.; and Joseph W. Phillips, Ph.D., *Major, United States Army.* Cloth. Pages xvi+568+lvi. 13.5×21 cm. 1943. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $2.00.

This is a book for the eleventh and twelfth year students written by authors who know both pupils and the subject. The text is divided into seven major units which cover the entire field of flying. It is an excellent textbook for high school students.

AERODYNAMICS FOR MODEL AIRCRAFT, by Avrum Zier. Cloth. 259 pages. 14×21.5 cm. 1942. Dodd, Mead and Company, 432 Fourth Avenue, New York, N. Y. Price $3.00.

Here is a textbook for the high school student on the construction and flight of model planes. It makes continuous use of formulas and problems. Many diagrams, graphs and pictures are used. The problems are solved by use of the slide-rule.

AERONAUTICS WORKBOOK, by Cornelius H. Siemens, *Assistant Professor, University of California, Berkeley, Calif. Educational Consultant, Civil Aeronautics Administration.* Paper. Pages iii+174. 18×27.5 cm. 1942. Ginn and Company, Statler Building, Boston, Mass. Price $1.00.

This is a laboratory workbook consisting of seventy-five problems: eighteen on aerodynamics, seventeen on meteorology, twenty on avigation, eight on the power plant, and twelve on the mathematics, graphs, formulas, etc. of aeronautics.

COPPER-COVERED STEEL WIRE JUST AS GOOD AS PURE COPPER FOR HIGH-FREQUENCY COMMUNICATION

Improved design of high-frequency telephone wires and other wartime communication lines, effecting a saving of strategic copper, may be possible from research work by Dr. B. R. Teare, Jr., and his assistant, Mrs. Josephine R. Webb, of the Carnegie Institute of Technology.

Copper-covered steel wire is just about as good as solid copper wire except at the lowest frequencies, the scientists discovered. Wide use is being made of a copper covering welded to a steel core because the great strength of this wire permits poles for the wires to be spaced far apart and saves large quantities of copper.

Resistance of copper-covered steel at ordinary power frequencies was known, but performance in the increasingly important range up to 150,000 cycles had not been charted previously.

Communication systems can be designed to fit both the material available and wartime requirements without the delay of testing the conductor by using the formulas announced by Dr. Teare and Mrs. Webb in their report.

CARROT JUICE COCKTAIL

Carrot juice cocktail in a cellophane package is one of the latest wartime products. By dehydration a cocktail powder is prepared which contains celery and salt as well as carrots. Packed in moistureproof, airtight, laminated cellophane packages, the product not only saves metal cans, but much weight. Only 2¼ pounds of the powder makes the equivalent of 96 twelve-ounce cans of cocktail juice weighing 103 pounds.

NATIONAL YOUTH POLICY

The ten points of the basic "National youth policy" are as follows:

(1) School attendance laws and child-labor standards embodied in State and Federal laws should be preserved and enforced.

(2) No one under 14 years of age should be employed full-time or part-time as a part of the hired labor force.

(3) Youth under 18 years of age may properly be employed only at wages paid adult workers for similar job performance and in work suited to their age and strength, avoiding all occupations that are hazardous or detrimental to health or welfare.

(4) Youth aged 14 or 15 may properly be employed only when qualified older workers are not available; and the employment is not in manufacturing or mining occupations.

(5) In-school youth may properly be employed only to the extent that the combined school and work activities involve no undue strain, and that combined school and work hours, at least for youth under 16, do not exceed 8 per day.

(6) In-school youth should not be employed during school hours unless the Area or Regional Manpower Director has determined that temporary needs of an emergency character cannot be met by full use of other available sources of labor.

(7) When war-time emergency cooperative arrangements have been entered into with school authorities for the part-time employment of in-school youth as a part of the school program, the employer should be responsible for certifying to the school authorities that such employment will be in conformity with State and Federal laws governing employment of of minors.

(8) When it is necessary to transport young people to and from work, safe and adequate means of transportation should be provided. The period of work and transportation should not exceed 10 hours a day.

(9) Where youth under 18 years of age are recruited in groups for agricultural work requiring them to live away from home assurances should be furnished by appropriate community or other agencies that suitable living conditions, sanitary facilities, health protection, supervision, and leisure-time activities will be provided. In no case should youth aged 14 or 15 be recruited for work requiring them to live away from home except where such work is in connection with programs conducted by recognized youth-serving agencies that provide close supervision.

(10) Any youth interested in work in another area should not leave his own area in search of work without first registering for employment at the nearest local office of the United States Employment Service or other agency designated by the War Manpower Commission.

ERRATUM

In the article on "Victory Gardens" in our February issue the first paragraph on page 121 should have read as follows: "Early in May, bush beans, beets, carrots and radishes were planted. The tomatoes were transplanted and protected from the frost and too severe drying winds."

When you change address be sure to notify Business Manager Mrs. W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.